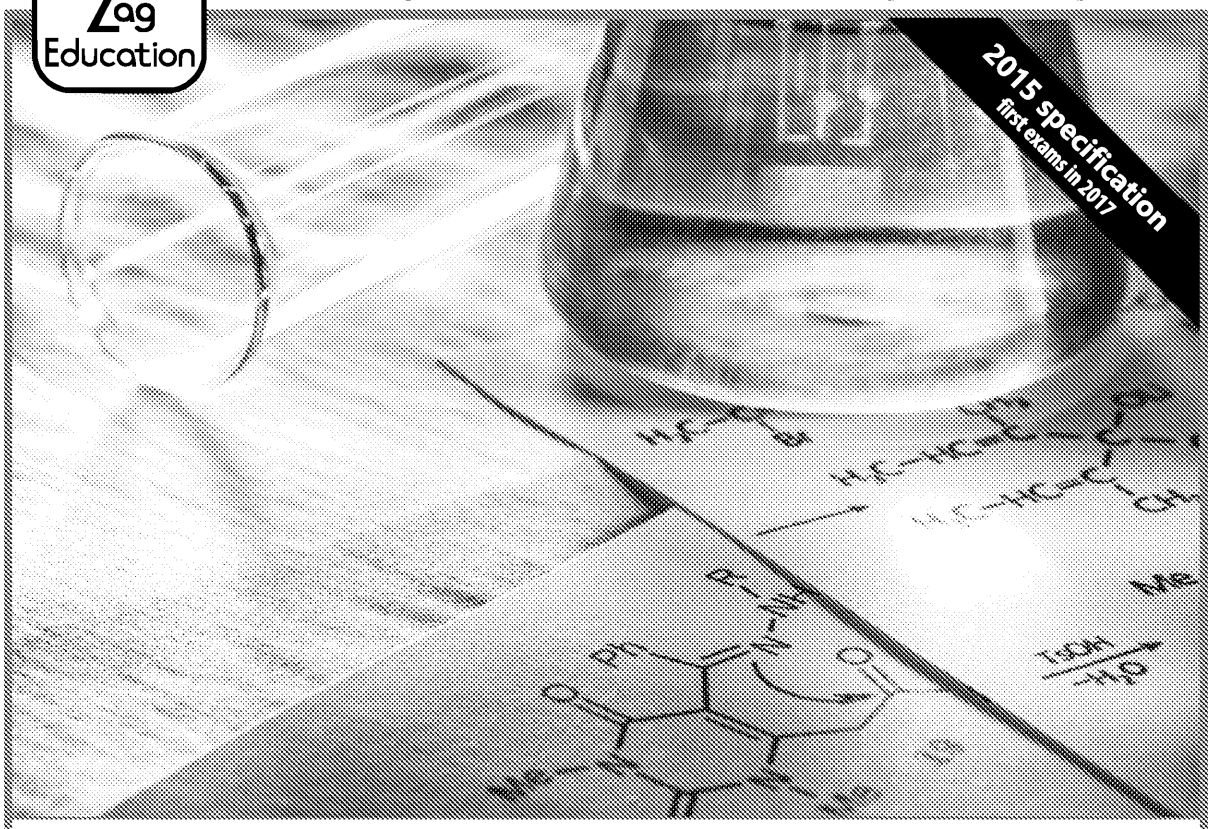
Zig Zag Education

Chemistry

A Level | Edexcel | 9CH0



Multiple-Choice Practice Questions

For A Level (Year 2) Edexcel Chemistry

zigzageducation.co.uk

POD 11759

Contents

Teacher's Introduction

For the A Level Year 2 Chemistry course, the Edexcel exam board includes a strong emphasis on multiple-choice questioning in both Paper 1 and Paper 2.

Remember!
Always check the exam board website for new information, including changes to the specification and sample assessment material.

Chemistry students sometimes find the multiple-choice questions testing; the format of the questions often challenges how complete the students' understanding is of the course and requires quick and accurate problem-solving to complete all the questions in the time given.
This multiple-choice question bank has been designed with the intention of providing students with the opportunity to review their multiple-choice skills and to practise and familiarise themselves with the questioning format with an extensive spread of multiple-choice questions from the Year 2 A Level course.

The resource is split into two sections:

Section A: Multiple-choice Question Bank 1
This section includes over 100 multiple-choice questions that span each of the topics making up the Year 2 A Level content. The questions mimic the exam style of the Edexcel exam board and reflect the depth, difficulty and format of the questions the students will face in their upcoming exam.

A mark scheme is provided at the section, which includes the answers along with worked solutions. The step-by-step solutions, and additional commentary to accompany them, give students an opportunity to identify the areas that still need improvement, and also to see where any mistakes were made and correct them for next time.

Section B: Multiple-choice Question Bank 2
This section includes another set of multiple-choice questions that similarly span each of the topics that make up the Year 2 A Level course. The questions deliberately mimic those presented to the student in Section A; this has been done so that, after working through the worked solutions of Section A, students can complete another set of questions and directly compare their attempts. The format allows students to correct their mistakes from Section A, identify areas where they have improved their understanding and highlight areas that still require further work.

A mark scheme for Section B is also provided at the end of the section. The mark scheme does not include worked solutions.

June 2022

Student's Introduction

Aim:
This pack is designed to help you practice your multiple-choice questions and, w
you to build effective strategies for completing these questions. Multiple-choice
Paper 2, and this pack aims to provide you with the tools to confidently tackle th

Structure:
The pack is comprised of two sections. Each section contains over 100 multiple-c
structure and level of the questions you will see in your exam. The questions of
areas that make up the A Level Year 2 Chemistry content:

- Physical Chemistry
- Organic Chemistry
- Inorganic Chemistry

After the questions, there are two sections of answers. The answers to Section A
additional commentary that indicates where you went wrong and provides an in
should have been approached. This will allow you to identify your mistakes and
tackle future questions. The answers to Section B do not provide any worked so

How to use this pack:

- You should first complete the questions in Section A.
- After you have completed the questions, you can then proceed by self-mark
  worked answers and commentary given in the answers section. You should
  Section A, taking note of your mistakes and ensuring that you understand w
  continuing with Section B.
- After completing Section B, you can proceed by self-marking your solutions
  Additionally, you can compare your answers to those obtained in Section A
  improved your skills and identify areas that still need further work.

Topic 1: Equilibrium II

1. The following statements are definitions of terms related to gas-phas
They may or may not be correct.

Which of the following statements is/are true?

1: The *mole fractions* of all of the components in a mixture of gases n
2: The *partial pressures* of all of the components in a mixture of gase
3: The *partial pressure* of any single component in a mixture of gases
the *mole fraction* of that component by the total pressure of the ga

A 1, 2 and 3

B Only 1 and 2

C Only 1 and 3

D Only 3

2. Hydrogen iodide forms an equilibrium mixture with the elements hy

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)} \quad \Delta H = +ve$$

Which of the following would cause the position of equilibrium to mo

A An increase in temperature at constant pressure

B A decrease in temperature at constant pressure

C An increase in pressure at constant temperature

D A decrease in pressure at constant temperature

3. In the following equilibrium, all of the chemicals are gases:

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

When equilibrium is reached, the mole fractions of PCl_3 and Cl_2 are b
of the system is 102.0 kPa. Which of the following shows the correct
chemicals?

A PCl_5 = 38.25 kPa; PCl_3 = 38.25 kPa; Cl_2 = 38.25 kPa

B PCl_5 = 34.00 kPa; PCl_3 = 34.00 kPa; Cl_2 = 34.00 kPa

C PCl_5 = 0.2500 kPa; PCl_3 = 0.3750 kPa; Cl_2 = 0.3750 kPa

D PCl_5 = 25.50 kPa; PCl_3 = 38.25 kPa; Cl_2 = 38.25 kPa

4. Which is the correct expression for K_p for the following reaction?

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$

A $K_p = \dfrac{p_{NH_3}}{p_{N_2} p_{H_2}}$

B $K_p = \dfrac{p_{N_2} p_{H_2}}{p_{NH_3}}$

C $K_p = \dfrac{p_{N_2} (p_{H_2})^3}{(p_{NH_3})^2}$

D $K_p = \dfrac{(p_{NH_3})^2}{p_{N_2} (p_{H_2})^3}$

5. Dinitrogen tetroxide forms an equilibrium mixture with its decompo
dioxide, as shown by the following equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

At 50 °C the equilibrium constant K_p = 283 kPa. If the partial pressur
the partial pressure of NO_2?

A 39100 kPa

B 198 kPa

C 0.698 kPa

D 0.488 kPa

6. Which of the following statements correctly describes the effect of ad
equilibrium reaction?

A The reaction will take the same amount of time to reach a state o
of K_p and the position of equilibrium will be unaffected

B The reaction will reach a state of equilibrium in a shorter time; th
unaffected but the position of equilibrium will be different.

C The reaction will take the same amount of time to reach a state o
of K_p and the position of equilibrium will be different.

D The reaction will reach a state of equilibrium in a shorter time; th
position of equilibrium will be unaffected

7. Changes in conditions can affect chemical equilibria and may cause t
constant to change. Which of the following statements correctly desc
temperature and pressure and the presence of a catalyst affect the fol

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -198 \text{ kJ mo}$$

A K_p will:
- decrease with increasing temperature
- increase with increasing pressure
- be unchanged if a catalyst is added

B K_p will:
- decrease with increasing temperature
- increase with increasing pressure
- increase if a catalyst is added

C K_p will:
- decrease with increasing temperature
- be unchanged with increasing pressure
- be unchanged if a catalyst is added

D K_p will:
- increase with increasing temperature
- be unchanged with increasing pressure
- be unchanged if a catalyst is added

Topic 2: Acid-Base Equilibria

1. Which of the following statements about aqueous acids and bases is/a

   1: Brønsted–Lowry acids are proton acceptors.
   2: Ammonia, NH_3, is a Brønsted–Lowry acid.
   3: Brønsted–Lowry bases are defined as sources of OH^- ions.

   A Only 1
   B Only 1 and 2
   C Only 2 and 3
   D None of the statements

2. Which of the following is not a Brønsted–Lowry acid–base reaction?

   A $H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$
   B $C_2H_4 + H_2 \rightarrow C_2H_6$
   C $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$
   D $2HCl + MgO \rightarrow MgCl_2 + H_2O$

3. Which of the following is the correct mathematical expression for the K_a, for a solution of a *monoprotic* weak acid (i.e. a weak acid where ea more than one H^+ ion) with the formula C_6H_5OH?

   A $K_a = \frac{[H^+]^2}{[C_6H_5OH]}$

   B $K_a = \frac{[H^+]}{[C_6H_5OH]}$

   C $K_a = \frac{[C_6H_5OH]}{[H^+]}$

   D $K_a = \frac{[C_6H_5OH]}{[H^+]^2}$

4. Which of the following statements about the ionic product of water, K

   1: K_w has a constant value that does not change.
   2: K_w is defined mathematically as $[H^+][OH^-]$.
   3: K_w is a small number because water does not significantly di

   A Only 1
   B Only 1 and 2
   C Only 2 and 3
   D 1, 2 and 3

5. What is the pH of a solution of H_2SO_4 with a concentration of 0.1 mo

A 1

B 0.7

C -1

D -0.7

6. If a solution of a strong *monoprotic* acid (i.e. an acid that dissociates t mole of acid molecule) has a pH of 1.3, what is the concentration of t

A 0.050 mol dm^{-3}

B 20 mol dm^{-3}

C 0.11 mol dm^{-3}

D 13 mol dm^{-3}

7. What is the pH of a solution of sodium hydroxide with a concentrat

A 2.6

B 16.6

C 12

D 11.4

8. A solution of a weak acid, HA, with a concentration of 0.250 mol dr What is the pK_a value for this acid?

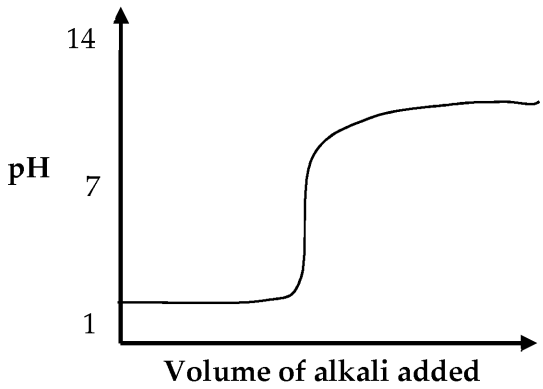
A 3.19

B 6.48×10^{-4}

C 1.05×10^{-7}

D 6.98

9. The diagram below shows an acid–base titration curve. Which com produce this curve?



A Ethanoic acid titrated against ammonia

B Sulfuric acid titrated against ammonia

C Ethanoic acid titrated against sodium hydroxide

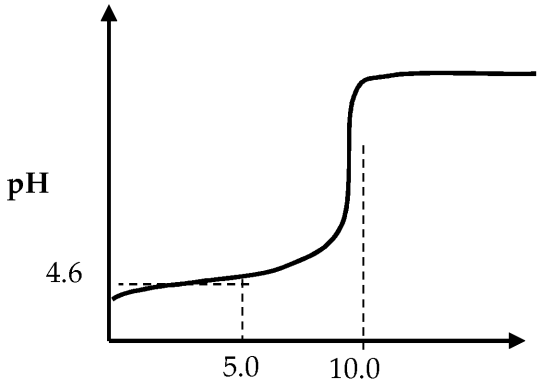
D Sulfuric acid titrated against sodium hydroxide

10. The table below shows the pH range at which various indicators cl
should you use to give an accurate result in a titration of hydrochlo

Indicator	pH range ov
Indicator 1	
Indicator 2	
Indicator 3	
Indicator 4	

A Indicator 1
B Indicator 2
C Indicator 3
D Indicator 4

11. Use the following pH curve to calculate the K_a of the acid involved



A 4.6
B 5.0
C 4.0×10^{4}
D 2.5×10^{-5}

12. Which of the following mixtures could form a *buffer solution*?

1: Methanoic acid and sodium methanoate
2: Sulfuric acid and sodium sulfate
3: Ethanoic acid and sodium methanoate

A Only 1
B Only 1 and 2
C Only 2 and 3
D None of the mixtures

13. Benzoic acid has a K_a value of 6.46×10^{-5}. What would be the pH o
mixing equal volumes of a 0.10 mol dm^{-3} solution of benzoic acid a
sodium benzoate?

A 3.89
B 4.49
C 4.19
D 5.19

Topic 3: Energetics II

1. Which of the following is the correct definition for the term *lattice ene*

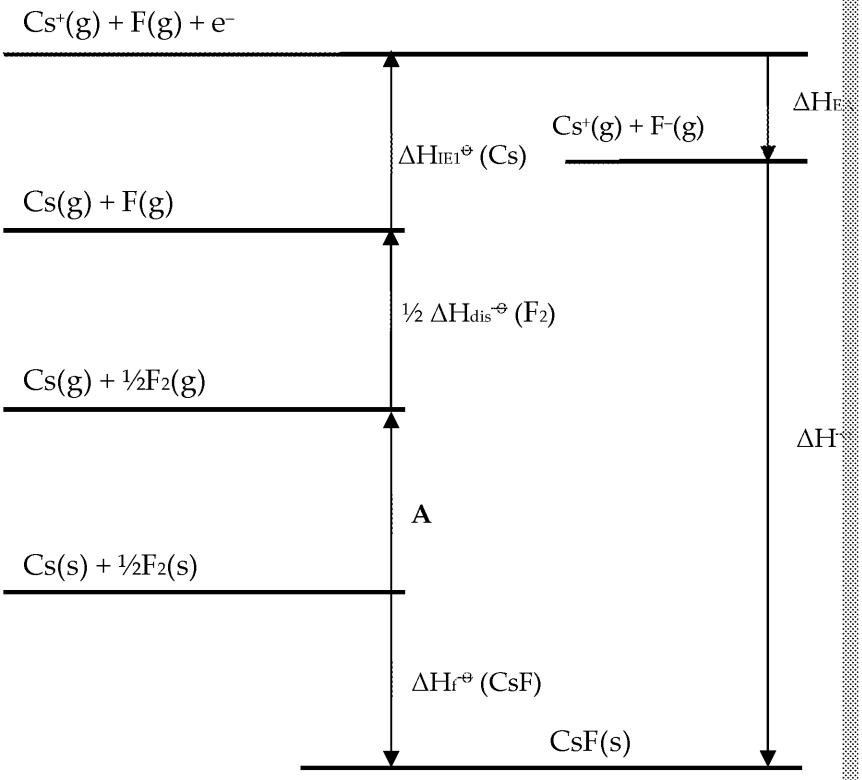
   A The energy change accompanying the formation of an ionic com from one mole of ions

   B The energy change accompanying the formation of one mole of a gas phase from its ions

   C The energy change accompanying the formation of one mole of a free ions in the gas phase

   D The energy change accompanying the formation of an ionic com free ions in the gas phase

2. What name is given to the letter A?



   A Standard enthalpy of atomisation of caesium

   B Standard enthalpy of evaporation of caesium

   C Standard enthalpy of formation of caesium

   D Bond enthalpy of caesium

3. Use the Born–Haber cycle in the previous question and the data bel
enthalpy of formation for CsF.

Enthalpy change	Energy (kJ mo
$\Delta H_f^e(CsF)$	-554
A	+77
$\Delta H_{DIS}^e(F_2)$	+79
$\Delta H_{IE1}^e(Cs)$	+376
$\Delta H_{EA1}^e(F)$	-328

A +350
B -718.5
C -758
D +389.5

4. Use the data below to calculate the enthalpy of solution for calcium

$\Delta H^e_{LAT(formation)}(CaBr_2) = -2176$ kJ mol^{-1}; $\Delta H^e_{HYD}(Ca^{2+}) = -1650$ kJ mo

A +1014 kJ mol^{-1}
B -4500 kJ mol^{-1}
C +189 kJ mol^{-1}
D -148 kJ mol^{-1}

5. The table of data below shows the calculated lattice energy (assumin
lattice energy derived from experimental data using a Born–Haber c
which of the ionic compounds, A to D, has the greatest covalent cha

Compound	Calculated lattice energy /kJ mol^{-1}	Born–Haber lattice energy /kJ mol^{-1}
A	828	879
B	774	789
C	713	728
D	683	691

6. Which of the following equations correctly represents the first ionisa
A $Na(s) + e^- \rightarrow Na^-(g)$
B $Na(s) \rightarrow Na^+(s) + e^-$
C $Na(s) + e^- \rightarrow Na^-(s)$
D $Na(g) \rightarrow Na^+(g) + e^-$

7. Which of the following shows the set of compounds in the correct orc
highest entropy?

A $CO_2(s)$, $CO_2(aq)$, $CO_2(g)$

B $CO_2(g)$, $CO_2(s)$, $CO_2(aq)$

C $CO_2(aq)$, $CO_2(g)$, $CO_2(s)$

D $CO_2(aq)$, $CO_2(s)$, $CO_2(g)$

8. Calculate the change in entropy of the following reaction, using the d

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

	Molar entropy, S_m /J K^{-1} mol^{-1}
$H_2(g)$	130.6
$Cl_2(g)$	223.0
HCl(g)	186.8

A -166.8 J K^{-1}

B +20.0 J K^{-1}

C -20.0 J K^{-1}

D +166.8 J K^{-1}

9. Based on the Gibbs equation, $\Delta G = \Delta H - T\Delta S$, which of the following

A For an endothermic reaction with ΔS = +ve, the reaction is more l
spontaneously at high temperature than at low temperature.

B For an endothermic reaction with ΔS = -ve, the reaction is more li
spontaneously at high temperature than at low temperature.

C For an exothermic reaction with ΔS = -ve, the reaction is more lik
spontaneously at high temperature than at low temperature.

D For an exothermic reaction with ΔS = +ve, the reaction will not be
temperature.

10. At room temperature (298 K), a chemical reaction with ΔH = +108.0 k
ΔS = + 96.00 J K^{-1} mol^{-1} does not occur spontaneously. Use the equati
minimum temperature at which the reaction becomes feasible.

A 1.125 K

B 1.125×10^3 K

C 8.889×10^{-4} K

D 0.8889 K

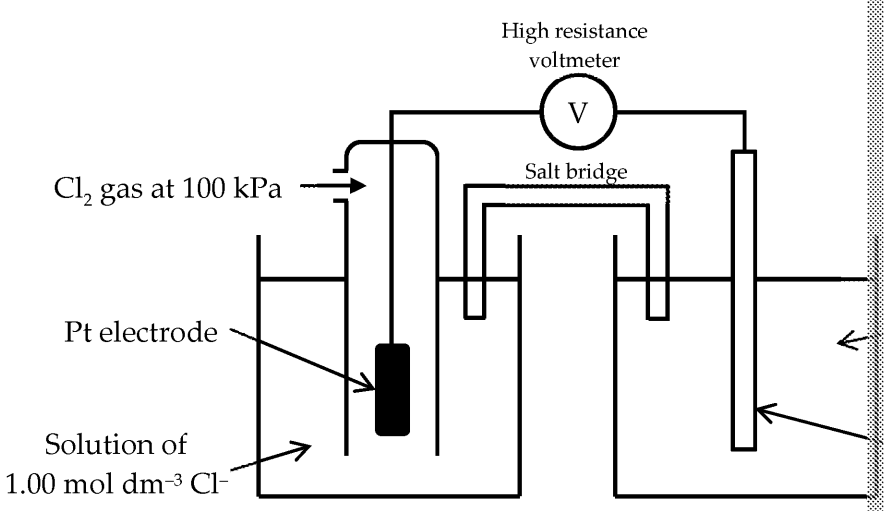
Topic 4: Redox II

1. Which of the following half-equations correctly follow(s) the IUPAC c
reactions at electrodes?

   1: $Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$
   2: $Fe^{2+}(aq) \rightleftharpoons Fe^{3+}(aq) + e^-$
   3: $Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$

   A Only half-equation 2
   B Half-equations 1 and 2
   C Half-equations 1 and 3
   D Half-equations 1, 2 and 3

2. Which is the correct conventional representation of the electrochemica
diagram below?



   A $Fe(s)|Fe^{2+}(aq)||Cl^-(aq)|Cl_2(g)|Pt(s)$
   B $Fe(s)|Fe^{2+}(aq)||Cl_2(g)|Cl^-(aq)|Pt(s)$
   C $Fe(s)|Fe^{2+}(aq)|Cl^-(aq)|Cl_2(g)|Pt(s)$
   D $Fe(s)|Fe^{2+}(aq), Fe^{3+}(aq)||Cl_2(g)|Cl^-(aq)|Pt(s)$

3. Which of the following can affect the value of the electrode potential o

$Zn(s)|Zn^{2+}(aq)||$

   1: The temperature of the room
   2: The pressure of the room
   3: The concentration of the solution of Zn^{2+} ion

   A Only 1
   B Only 1 and 3
   C Only 2 and 3
   D 1, 2 and 3

4. Use the data given below to select which of the following reactions w
favourable electrochemical potential.

Half-cell				Standard electro
$2H^+(aq)$	+	$2e^-$	$\rightleftharpoons H_2(g)$	
$Ag^+(aq)$	+	e^-	$\rightleftharpoons Ag(s)$	
$Zn^{2+}(aq)$	+	$2e^-$	$\rightleftharpoons Zn(s)$	

A Silver ions and zinc metal

B Hydrogen gas and silver ions

C Silver metal and zinc ions

D Zinc metal and hydrogen ions

5. Use the data given below to calculate the cell potential of an electrocl
standard hydrogen electrode as the anode and a piece of copper dipp
solution of copper(II) chloride as the cathode.

Half-cell				Standard electro
$2H^+(aq)$	+	$2e^-$	$\rightleftharpoons H_2(g)$	
$Cu^{2+}(aq)$	+	$2e^-$	$\rightleftharpoons Cu(s)$	
$Cu^{2+}(aq)$	+	e^-	$\rightleftharpoons Cu^+(aq)$	

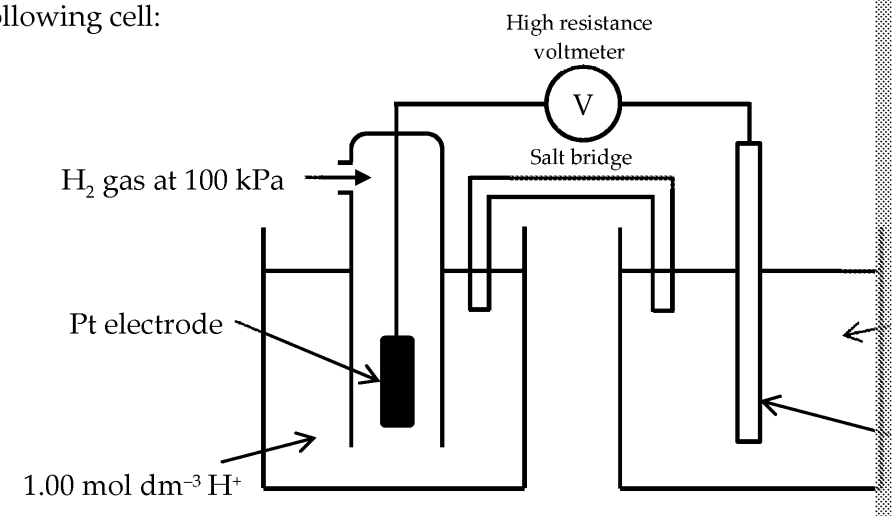
A 0.15 V

B 0.34 V

C -0.15 V

D -0.34 V

6. A student measures the electrode potential for the copper(II)/copper(I
following cell:



Her lab partner says that what has been measured is not a *standard* el
the conditions is non-standard?

A The hydrogen gas is at the wrong pressure.

B The temperature is wrong.

C The concentrations of the copper ions are wrong.

D The concentration of the hydrogen ions is wrong.

7. Under standard conditions, the cell potential, E^{θ}, for each of the two c

$Mg(s)|Mg^{2+}(aq)||Ag^{+}(aq)|Ag(s)$ $E^{\theta} = +3.1$
$Cu(s)|Cu^{2+}(aq)||Fe^{2+}(aq)|Fe(s)$ $E^{\theta} = -0.75$

Use this information to decide which of the following shows the corr
if these cells were set up.

A $Mg(s) + 2Ag^{+}(aq) \rightarrow Mg^{2+}(aq) + 2Ag(s)$ and $Fe^{2+}(aq) + Cu(s) \rightarrow Fe(s$

B $Mg^{2+}(aq) + 2Ag(s) \rightarrow Mg(s) + 2Ag^{+}(aq)$ and $Fe^{2+}(aq) + Cu(s) \rightarrow Fe(s$

C $Mg^{2+}(aq) + 2Ag(s) \rightarrow Mg(s) + 2Ag^{+}(aq)$ and $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}$

D $Mg(s) + 2Ag^{+}(aq) \rightarrow Mg^{2+}(aq) + 2Ag(s)$ and $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}$

8. One type of fuel cell uses the reaction of methanol with oxygen to prod
equation for the reaction in the fuel cell and the half-equation for the ne

Overall: $CH_3OH + 1\frac{1}{2}O_2 \rightarrow CO_2 + 2H_2O$
Negative electrode: $CH_3OH + H_2O \rightarrow CO_2 + 6H^{+} + 6e^{-}$

Which of these is the correct half-equation for the reaction at the posi
such a way that it will combine with the negative electrode half-equa
equation as it is shown above?

A $1\frac{1}{2}O_2 + 6H^{+} + 6e^{-} \rightarrow 3H_2O$

B $\frac{1}{2}O_2 + 2H^{+} + 2e^{-} \rightarrow H_2O$

C $1\frac{1}{2}O_2 + 6H^{+} + 6e^{-} \rightarrow 2H_2O$

D $O_2 + 4H^{+} + 6e^{-} \rightarrow 2H_2O$

9. What type of cell has the electrode reactions shown below?

Positive electrode: $Li^{+} + CoO_2 + e^{-} \rightarrow Li^{+}[CoO_2]^{-}$
Negative electrode: $Li \rightarrow Li^{+} + e^{-}$

A Fuel cell

B Non-rechargeable cell

C Rechargeable cell

D Irreversible cell

10. Which of the following shows the correct equations for the electrode reac
oxygen fuel cell, along with the correct explanation of how an electric cu

A The reaction at the negative electrode is $2H_2 + 4OH^{-} \rightarrow 4H_2O + 4e$
electrons which travel **internally** through a salt bridge to the posi
reaction uses these electrons: $O_2 + 2H_2O + 4e^{-} \rightarrow 4OH^{-}$.

B The reaction at the negative electrode is $4OH^{-} \rightarrow O_2 + 2H_2O + 4e^{-}$.
which travel around an **external** circuit to the positive electrode,
these electrons: $4H_2O + 4e^{-} \rightarrow 2H_2 + 4OH^{-}$.

C The reaction at the negative electrode is $4OH^{-} \rightarrow O_2 + 2H_2O + 4e^{-}$.
which travel **internally** through a salt bridge to the positive elect
uses these electrons: $4H_2O + 4e^{-} \rightarrow 2H_2 + 4OH^{-}$.

D The reaction at the negative electrode is $2H_2 + 4OH^{-} \rightarrow 4H_2O + 4e$
electrons which travel around an **external** circuit to the positive e
reaction uses these electrons: $O_2 + 2H_2O + 4e^{-} \rightarrow 4OH^{-}$.

Topic 5: Transition Metals

1. Which of these shows the correct electronic configuration for a transitic periodic table?

   A $[Ar]3d^5 4s^1$

   B $[Ar]3d^{10} 4s^2$

   C $[Kr]3d^5 4s^1$

   D $[Kr]3d^{10} 4s^2$

2. Which of these explanations of the toxicity of carbon monoxide is corre

   A Carbon monoxide is toxic because it forms a strong ionic bond to groups, taking the place of oxygen and reducing the oxygen-carry

   B Carbon monoxide is toxic because it forms a coordinate bond to t taking the place of oxygen and reducing the oxygen-carrying cap

   C Carbon monoxide is toxic because it forms a coordinate bond to t groups, taking the place of oxygen and reducing the oxygen-carry

   D Carbon monoxide is toxic because it forms a covalent bond to oxyg binding to the Fe(II) in haem groups and so reduces the oxygen-ca

3. The following equilibrium lies very far to the right-hand side (the value What is the correct explanation for this?

   $$[Ni(H_2O)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightleftharpoons [Ni(H_2NCH_2CH_2N$$

   A The reaction is very exothermic because so many bonds are being number that are broken.

   B The increase in the number of molecules during the reaction caus entropy.

   C The production of water, which is a very stable molecule, results enthalpy.

   D $[Ni(H_2O)_6]^{2+}$ is an unstable ion and spontaneously reacts with many

4. Which of the following is/are correct in describing $Pt(NH_3)_2Cl_2$? Give

   1: It is a tetrahedral complex ion.
   2: It has a coordination number of 4.
   3: It has cis and trans isomers.

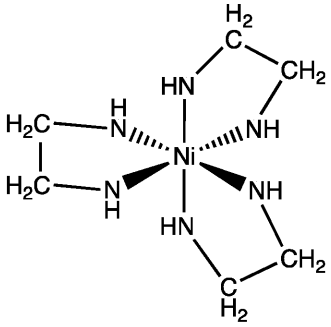
   A 1 only

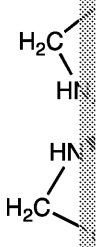
   B 2 only

   C 2 and 3

   D 1, 2 and 3

5. Which type of isomerism is shown by these two structures?





A Cis-trans isomerism
B Geometrical isomerism
C E/Z isomerism
D Optical isomerism

6. Which is the correct description for the reaction shown below?

$$[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6$$

A Complete ligand substitution with a change of coordination num
B Incomplete ligand substitution with a change of coordination nu
C Complete ligand substitution with a change from monodentate t
D Incomplete ligand substitution with a change of ligand size

7. Which of these is/are a correct set of characteristics typical of *transitio*

1: Formation of coloured ions
2: Catalytic activity
3: Variable oxidation state

A 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

8. When $FeCl_2$ solution is added to a solution of KI and $Na_2S_2O_8$, the rate but the amount of $FeCl_2$ does not change. Which statement best expla

A The $FeCl_2$ acts as a homogeneous catalyst. Its ability to change fr do this.
B The $FeCl_2$ acts as a heterogeneous catalyst. Its ability to change fr to do this.
C The $FeCl_2$ acts as a homogeneous catalyst. Its ability to provide a reactants to adsorb onto allows it to do this.
D The $FeCl_2$ acts as a heterogeneous catalyst. Its ability to provide a reactants to adsorb onto allows it to do this.

9. Which of the following can affect the difference in energy, ΔE, betwe excited state of d-electrons in a transition metal complex ion?

1: A change in the oxidation state of the transition metal
2: A change in the coordination number of the transition metal
3: A ligand substitution reaction

A 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

10. Which of the following procedures could you use to observe the co
vanadium ions with vanadium in oxidation states V, IV, III and II?

A Add zinc to an acidified solution containing the $[VO(H_2O)_5]^{2+}$ io

B Add zinc to an acidified solution containing the VO_3^- ion

C Add potassium permanganate to an acidified solution containi

D Add potassium permanganate to an acidified solution containi

11. Which pair of equations correctly show V_2O_5 acting as a catalyst in

A $SO_2 + V_2O_5 \rightarrow SO_3 + V_2O_4$
$V_2O_4 + \frac{1}{2}O_2 \rightarrow V_2O_5$

B $SO_2 + V_2O_5 \rightarrow SO_3 + V_2O_4$
$V_2O_4 \rightarrow V_2O_3 + \frac{1}{2}O_2$

C $1\frac{1}{2}H_2 + V_2O_5 \rightarrow V_2O_2(OH)_3$
$V_2O_2(OH)_3 + \frac{1}{2}N_2 \rightarrow V_2O_5 + NH_3$

D $2\frac{1}{2}H_2 + V_2O_5 \rightarrow V_2(OH)_5$
$V_2(OH)_5 + \frac{1}{2}N_2 \rightarrow V_2O_3(OH)_2 + NH_3$

12. Which of the following reactions show(s) how the oxidation of C_2O

1. $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$
2. $4Mn^{2+} + MnO_4^- + 8H^+ \rightarrow 5Mn^{3+} + 4H_2O$
3. $2Mn^{3+} + C_2O_4^{2-} \rightarrow 2CO_2 + 2Mn^{2+}$

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

13. Which of the following statements describes what you would obse
hydroxide solution was added *dropwise* to separate solutions of alu
iron(III) chloride?

A A precipitate of $Fe(OH)_3$ would form and then disappear as m
precipitate of $Al(OH)_3$ would form and this too would disappe
was added.

B A precipitate of $Fe(OH)_3$ would form and would be unaffected
NaOH; a precipitate of $Al(OH)_3$ would form but would disap
was added.

C A precipitate of $Fe(OH)_3$ would form and would be unaffected
NaOH; a precipitate of $Al(OH)_3$ would form and also be unaff
was added.

D A precipitate of $Fe(OH)_3$ would form and then disappear as m
precipitate of $Al(OH)_3$ would form but would be unaffected as

14. Dimethylglyoxime is a bidentate ligand with the formula $C_4N_2O_2H$ DMGH. Which of the following equations best describes the reacti copper(II) nitrate with DMGH?

A $[Cu(H_2O)_4]^{2+}(aq) + 4DMGH(aq) \rightarrow [Cu(DMGH)_4]^{2+} + 4H_2O$

B $[Cu(H_2O)_4]^{2+}(aq) + 2DMGH(aq) \rightarrow [Cu(DMGH)_2]^{2+} + 4H_2O$

C $[Cu(H_2O)_6]^{2+}(aq) + 3DMGH(aq) \rightarrow [Cu(DMGH)_3]^{2+} + 6H_2O$

D $[Cu(H_2O)_6]^{2+}(aq) + 3DMGH(aq) \rightarrow [Cu(H_2O)_3(DMGH)_3]^{2+} + 3H$

15. Which of the following statements best explains why aqueous solu compounds are coloured?

A As white light passes through the solution, d electrons move a state of higher energy in the d-subshell. This causes certain be emitted.

B As white light passes through the solution, d electrons move a state at lower energy in the p-subshell. This causes certain be absorbed.

C As white light passes through the solution, d electrons move an excited state at higher energy. This causes certain wavele

D As white light passes through the solution, d electrons move a state at lower energy in the p-subshell. This causes certain be emitted.

16. 20.0 cm^3 of a solution of iron(II) chloride needed an average titre c solution of potassium dichromate to reach the end point. What w solution? Relevant half-equations are given below.

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$$
$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) +$$

A 1.94×10^{-3} mol dm^{-3}

B 9.71×10^{-2} mol dm^{-3}

C 1.62×10^{-2} mol dm^{-3}

D 0.111 mol dm^{-3}

17. Why do aqueous solutions of iron(III) salts have a pH below 2, wh iron(II) salts have a pH of 4 or above?

A The Fe(III) ion polarises water ligands more than the Fe(II) io more soluble than iron(II) salts

B The Fe(III) ion polarises water ligands more than the Fe(II) io release H^+ more readily when bonded to Fe(III) than when bo

C Fe(III) ions bond to OH^- ions more strongly than Fe(II) ions, a these ions from an aqueous solution.

D Fe(II) ions bond weakly to OH^- ions, Fe(III) ions bond strongl compounds release more OH^- ions into solution.

Topic 6: Kinetics II

1. Use the initial rates data below to help you select the correct rate equ

$$2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2$$

	[I⁻] / mol dm⁻³	[H₂O₂] / mol dm⁻³	[H⁺] / mol dm
1	0.030	0.036	0.003
2	0.015	0.036	0.003
3	0.030	0.009	0.003
4	0.030	0.009	0.006

A Rate = $k[I^-][H_2O_2][H^+]$

B Rate = $k[I^-][H_2O_2]$

C Rate = $k[I^-]^2[H_2O_2][H^+]^2$

D Rate = $k[I^-][H_2O_2]^2$

2. The rate of the reaction between NO and H_2 is given by the equation initial rates data below to choose the correct value for the rate consta

[NO] / mol dm⁻³	[H₂] / mol dm⁻³	Rate
0.0460	0.0130	

A 2.00×10^3 dm^6 mol^{-2} min^{-1}

B 9.33×10^{-6} dm^6 mol^{-2} min^{-1}

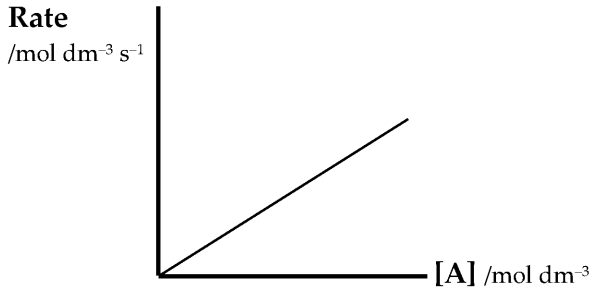
C 1.54×10^5 dm^6 mol^{-2} min^{-1}

D 7.18×10^{-4} dm^6 mol^{-2} min^{-1}

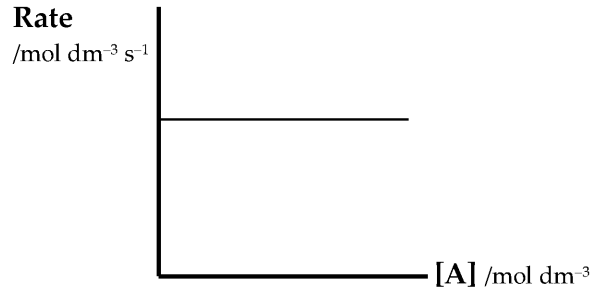
[Quest

3. If a reaction is zero order with respect to reactant A, which graph rep
reaction against concentration of A?

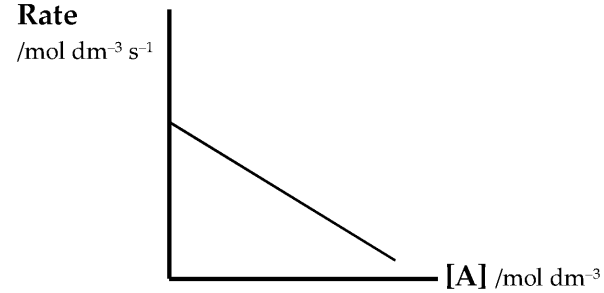
A



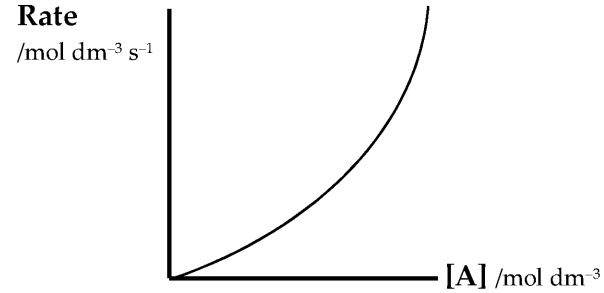
B



C



D



4. In the reaction of sodium thiosulfate ($Na_2S_2O_3$) with hydrochloric acic
produced. The data below shows how long a series of reactions took
that a mark under the reaction flask could no longer be seen. From tl
the reaction with respect to HCl and to $Na_2S_2O_3$?

[HCl] (mol dm^{-3})	[$Na_2S_2O_3$] (mol dm^{-3})	Time (s)
0.100	0.150	237
0.200	0.150	59
0.100	0.300	118

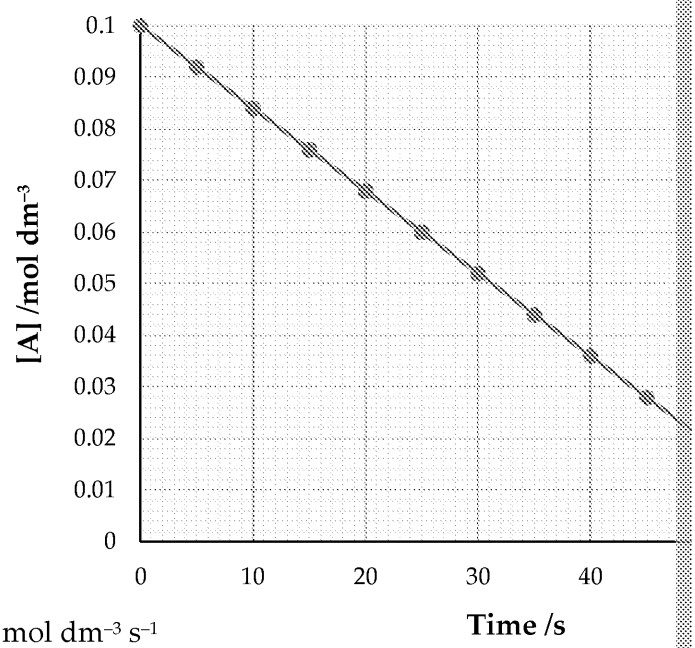
A Second order in HCl and first order in $Na_2S_2O_3$

B Second order in HCl and second order in $Na_2S_2O_3$

C First order in HCl and first order in $Na_2S_2O_3$

D First order in HCl and second order in $Na_2S_2O_3$

5. The following is a concentration–time graph for a zero-order reacti
following is the correct value for the rate constant for this reaction,



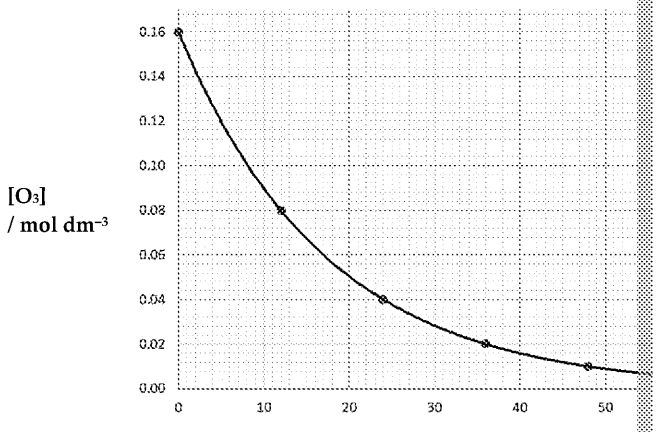
A -1.8×10^{-3} mol dm^{-3} s^{-1}

B 1.6×10^{-3} mol dm^{-3} s^{-1}

C -1.6×10^{-3} s^{-1}

D 625 s^{-1}

6. A concentration–time graph of the first-order decomposition reacti
Use the graph to determine the rate of decomposition of ozone 20 s
the reaction.



A 360 mol dm^{-3} s^{-1}

B 5.5×10^{-3} mol dm^{-3} s^{-1}

C 0.050 mol dm^{-3} s^{-1}

D 2.8×10^{-3} mol dm^{-3} s^{-1}

7. Benzenediazonium chloride reacts with water according to the follo

$$C_6H_5N_2Cl(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + HCl(aq) + N_2(g$$

This is a list of practical techniques that may be useful in monitorin

1: Measuring the change of pH over time
2: Measuring the volume of gas produced over time
3: Measuring the change in temperature over time

Which of these statements correctly describe(s) which techniques c
of reaction of benzenediazonium chloride with water?

A Only technique 1 – the others will not work for this reaction.

B Only technique 2 – the others will not work for this reaction.

C Techniques 1 and 2 can be used, but technique 3 will not work

D Techniques 1, 2 and 3 will all work with this reaction.

8. The oxidation of iodide ions by hydrogen peroxide in the presence
thiosulfate and a starch indicator is an example of a *clock* reaction.
two correct reasons why this is a convenient, practical way of deter

A There is an easily detectable change during the reaction; it is po
the initial rate of reaction before a significant amount of reactan

B There is an easily detectable change during the reaction; it is
of reaction at a point when most of the reactants have been u

C At least one of the reactants has a very intense colour and so
concentrations; it is possible to accurately estimate the initial
significant amount of reactants has been used up.

D At least one of the reactants has a very intense colour and so
concentrations; it is possible to measure the rate of reaction a
reactants have been used up.

9. Hydrogen reacts with iodine monochloride according to this overa

$$H_2(g) + 2ICl(g) \rightarrow 2HCl(g) + I_2(g)$$

the reaction mechanism consists of two steps:

Slow step: $H_2(g) + ICl(g) \rightarrow HI(g) + HCl(g)$
Fast step: $HI(g) + ICl(g) \rightarrow HCl(g) + I_2(g)$

Which of the following rate equations is consistent with this mecha

A Rate = $k[H_2][ICl]^2$

B Rate = $k[HI][ICl]$

C Rate = $k[H_2][ICl]$

D Rate = $k[H_2][HI][ICl]$

10. The Arrhenius equation can be expressed as $k = Ae^{-Ea/RT}$. What does
between the temperature, T, of a reaction and the value of the rate co

A As T increases, k will increase linearly.

B As T increases, k will decrease linearly.

C As T increases, k will increase exponentially.

D As T increases, k will decrease exponentially.

11. The Arrhenius equation can be converted into the following: ln k =
following correctly describes a graphical method of determining th

A Plot ln k against 1/T. The activation energy is found from the nega

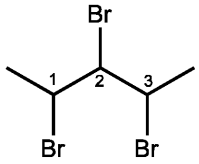
B Plot ln A against 1/T. The activation energy is found from the nega

C Plot ln k against 1/T. The activation energy is found from the p

D Plot ln A against 1/T. The activation energy is found from the p

Topic 7: Organic Chemistry II

1. Which of the carbons labelled is chiral in the following molecule?



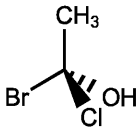
A None of them

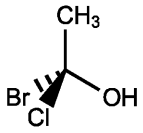
B 2 only

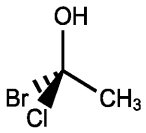
C 1 and 3 only

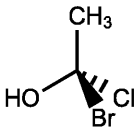
D 1, 2 and 3

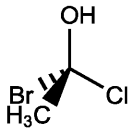
2. Which of the following molecules is an optical isomer of the molecu



A 

B 

C 

D 

3. What is the correct definition of the term *racemic mixture*?

A A mixture that contains a single chiral compound but with two

B A mixture that contains unequal amounts of the two enantiome molecule

C A mixture that contains only one kind of enantiomer from two compounds

D A mixture that contains equal amounts of two enantiomers of a

4. Which of the following reactions could be used to synthesise propa
that shows all of the possible reactions.

1: Reflux propan-1-ol with acidified potassium dichromate
2: Reflux propanone with acidified potassium dichromate
3: Reflux propanal with acidified potassium dichromate

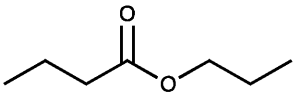
A 1 and 2 only
B 1 and 3 only
C 2 only
D 1, 2 and 3

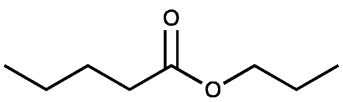
5. Which of the following reagents could be used to tell propanone an
A KCN
B Na_2CO_3
C $NaBH_4$
D $[Ag(NH_3)_2]^+$

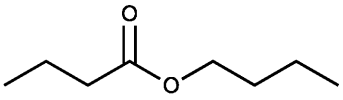
6. Which is the correct product of the reaction that occurs when KCN
dilute acid?
A propanenitrile
B ethanenitrile
C 2-hydroxypropanenitrile
D 2-hydroxyethanenitrile

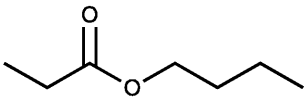
7. In the reaction that occurs when KCN is added to butanone, follow
isomeric products. Which of the following is the correct explanatio
A It is possible for the CN^- ion to add to butanone at two different
different positional isomers.
B The CN^- ion can add to either face of the flat C=O group, leadin
isomers.
C It is possible for the product to undergo a rearrangement, leadi
positional isomers.
D The flat C=O bond cannot rotate, causing two different optical i

8. Which of the following esters is propyl butanoate?

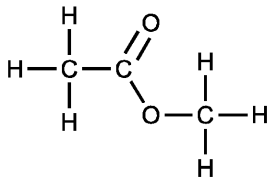
A


B


C


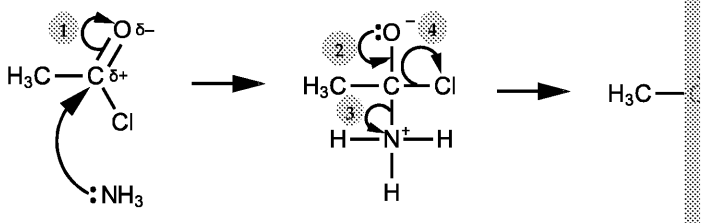
D


9. What are the products of the reaction of this ester with an aqueous sol



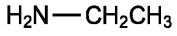
A Methanol and sodium ethanoate
B Ethanol and sodium methanoate
C Methanol and ethanoic acid
D Ethanol and methanoic acid

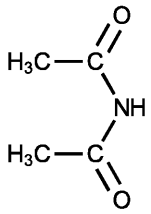
10. Which of the following arrows in the mechanism is **incorrect**?

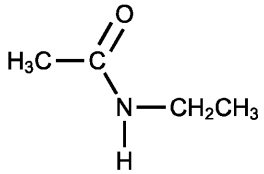


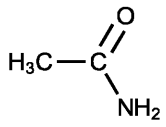
A 1
B 2
C 3
D 4

11. Which of the following is a product of the nucleophilic addition-elim
ethanoic anhydride and excess ammonia?

A 

B 

C 

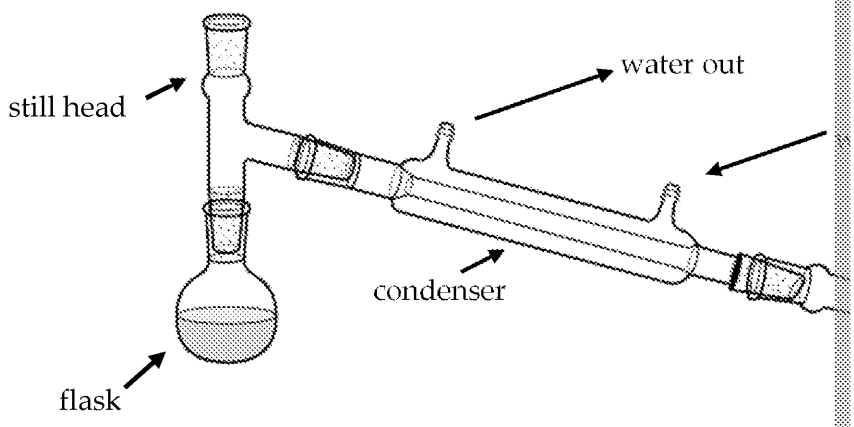
D 

12. Three organic compounds were tested with sodium carbonate, Tolle
potassium dichromate(VI). The results are shown in the table below
names the functional groups present in the compounds?

Compound	Result of adding sodium carbonate	Result of adding Tollens' reagent
1	no reaction	silver mirror forms
2	no reaction	no reaction
3	bubbles form	no reaction

A Compound 1 is an aldehyde; compound 2 is a ketone; compound
B Compound 1 is a ketone; compound 2 is an aldehyde; compound
C Compound 1 is an aldehyde; compound 2 is a carboxylic acid; co
D Compound 1 is a carboxylic acid; compound 2 is an aldehyde; co

13. The diagram below shows how apparatus has been set up in order t
What is wrong with the way in which the apparatus has been set up

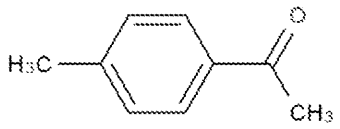


A The water is flowing the wrong way in the condenser.
B There is nothing in the still head to seal it.
C The receiver adaptor does not make an airtight seal with the con
D The condenser is at the wrong angle – it should be vertical.

Topic 8: Organic Chemistry III

1. Which of the following pieces of evidence helped to convince the scie
benzene molecules contain a delocalised π-system?
   A Less heat energy is absorbed during the hydrogenation of benzen
   multiplying the enthalpy of hydrogenation of cyclohexene by thre
   B Less heat energy is released during the hydrogenation of benzene
   multiplying the enthalpy of hydrogenation of cyclohexene by thre
   C More heat energy is absorbed during the hydrogenation of benze
   multiplying the enthalpy of hydrogenation of cyclohexene by thre
   D More heat energy is released during the hydrogenation of benzen
   multiplying the enthalpy of hydrogenation of cyclohexene by thre

2. Which of the following sets of reagents would convert methylbenzen



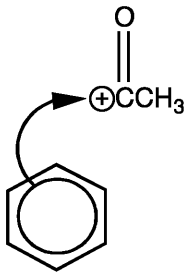
   A Chloroethane and $AlCl_3$
   B Chloroethane and sulfuric acid
   C Ethanoyl chloride and sulfuric acid
   D Ethanoyl chloride and $AlCl_3$

3. Why are substitution reactions of benzene much more common than
   A Addition reactions result in products without the full delocalised
   makes them less stable.
   B The benzene ring becomes overcrowded if too many atoms are ad
   products of addition reactions unstable.
   C Substitution reactions are favoured because the shape of the benz
   electrophiles to attack.
   D Electrophiles rarely undergo addition reactions – they usually rea

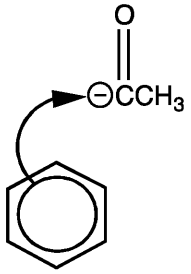
4. Aromatic compounds can be nitrated using a 'nitrating mixture' of co
sulfuric acid. Which of the following equations correctly shows how
the electrophile that attacks the benzene ring?
   A $H_2SO_4 + HNO_3 \rightarrow NO_3^- + H_3SO_4^+$
   B $2H_2SO_4 + HNO_3 \rightarrow NO_2 + H_3O^+ + 2SO_4^{2-}$
   C $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$
   D $2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$

5. Which of these is a correct step in the mechanism of electrophilic sub
ethanoyl chloride in the presence of a Friedel–Crafts catalyst?

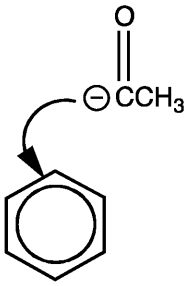
A



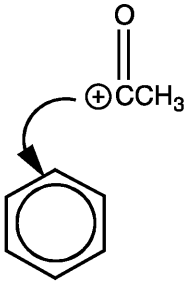
B



C



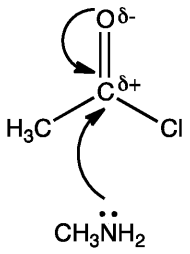
D



6. Which of the following shows the compounds in the correct order fr
   A Phenylamine < methylamine < ammonia
   B Ammonia < phenylamine < methylamine
   C Ammonia < methylamine < phenylamine
   D Phenylamine < ammonia < methylamine

7. Which of the following is a correct step in the mechanism of the rea
ethanoyl chloride?

A



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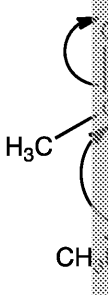
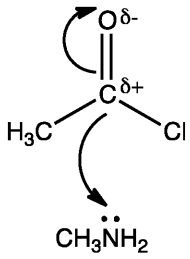
C



B



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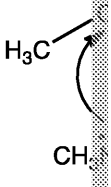
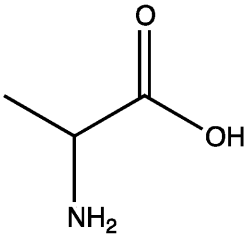


8. Which of the following structures is the correct one for the amino ac
(i.e. in acidic conditions)?

A



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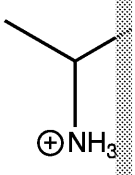
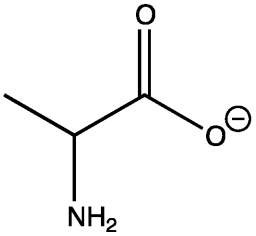
C



B



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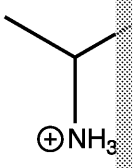
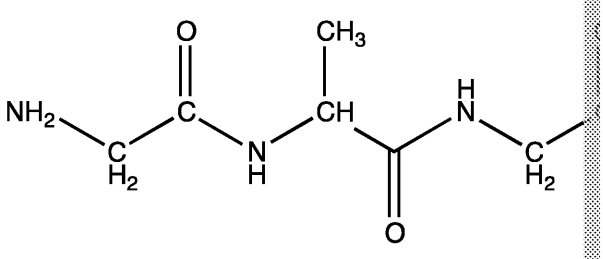
D



9. Which amino acids will be produced if this tripeptide is hydrolysed



A Only NH_2CH_2COOH

B NH_2CH_2COOH and $NH_2CH(CH_3)COOH$

C NH_2CH_2COOH, $NH_2CH(CH_3)COOH$ and $NH_2CH_2CONH_2$

D Only $NH_2CH(CH_3)COOH$

10. Which of the following statements about different types of bond and
    A Hydrogen bonds help maintain a protein's secondary and tertiar
    bonds help maintain the tertiary structure.
    B Hydrogen bonds help maintain a protein's secondary structure a
    help maintain the tertiary structure.
    C Sulfur–sulfur bonds help maintain a protein's secondary structu
    maintain the tertiary structure.
    D Sulfur–sulfur bonds help maintain a protein's secondary structu
    maintain the secondary and tertiary structures.

11. Which of the following is the correct way to synthesise 1-aminoprop
    chloroethane?
    A Reflux chloroethane with sodium cyanide in ethanol then react th
    and a nickel catalyst at high temperature and pressure.
    B Heat chloroethane with a large excess of ammonia dissolved in e
    then separate the product by distillation.
    C Reflux chloroethane with sodium cyanide in ethanol then reflux
    hydrochloric acid.
    D Reflux chloroethane with a large excess of ammonia dissolved in
    product by distillation.

12. Which of the following schemes is a possible way of making 2-hydrox

A

1. $CH_3CH_2CHO \xrightarrow{NaCN(aq)} CH_3CH_2CH(OH)CN$
2. $CH_3CH_2CH(OH)CN \xrightarrow{HCl(aq)} CH_3CH_2CH(OH)COOH$

B

1. $CH_3CH_2CHO \xrightarrow{NaBH_4} CH_3CH_2CH_2OH$
2. $CH_3CH_2CH_2OH \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH(OH)COOH$

C

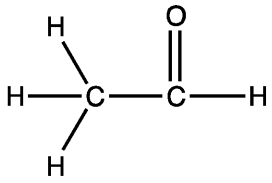
1. $CH_3CH_2CHO \xrightarrow{NaBH_4} CH_3CH_2CH(OH)CH_3$
2. $CH_3CH_2CH(OH)CH_3 \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH(OH)COOH$

D

1. $CH_3CH_2CHO \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH_2COOH$
2. $CH_3CH_2CH_2COOH \xrightarrow{NaOH(aq)} CH_3CH_2CH(OH)COOH$

Topic 9: Modern Analytical Techniqu

1. What would be the splitting patterns of the two signals in the ^1H NMI shown below?



A Quartet and doublet

B Triplet and singlet

C Triplet and doublet

D Two singlets

2. How many signals would you expect to see in the proton NMR spectr

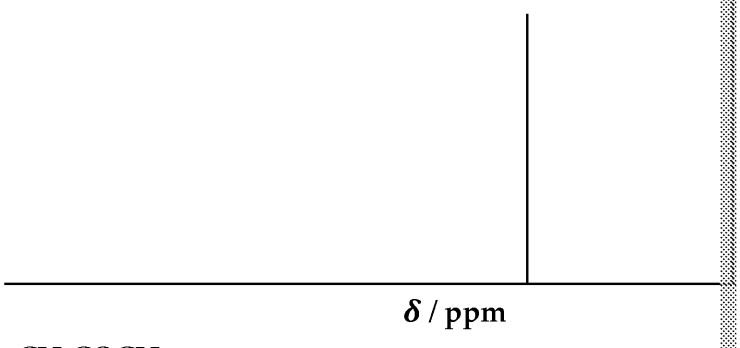
A 1

B 2

C 3

D 4

3. Which isomer with the formula C_3H_6O would give the carbon-13 NMI The chemical shift values of the peaks are not needed to answer this q



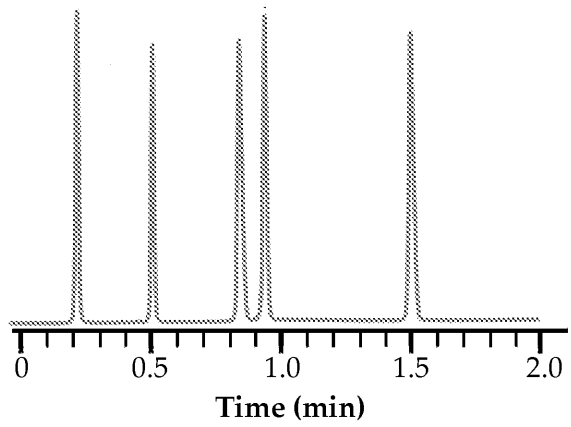
A Propanone, CH_3COCH_3

B Prop-2-ene-1-ol, CH_2CHCH_2OH

C Prop-1-ene-2-ol, $CH_2C(OH)CH_3$

D Propanal, CH_3CH_2CHO

4. Use the following gas chromatogram plus the table of data to identi
the mixture.



Compoun
methanol
ethanol
propan-1-o
propan-2-o
methanal
ethanal
propanal
propanon

A Methanol, ethanol, propanal, propan-1-ol

B Methanol, ethanal, ethanol, propanone, propan-1-ol

C Methanol, methanal, ethanal, ethanol, propanal, propan-1-ol

D Methanol, ethanal, ethanol, propanal, propan-1-ol

5. A mixture of compound A and compound B is passed through a co
Propanone is poured down the column and compound A emerges
Which of the following statements can explain this?

A Compound A is a smaller molecule than compound B.

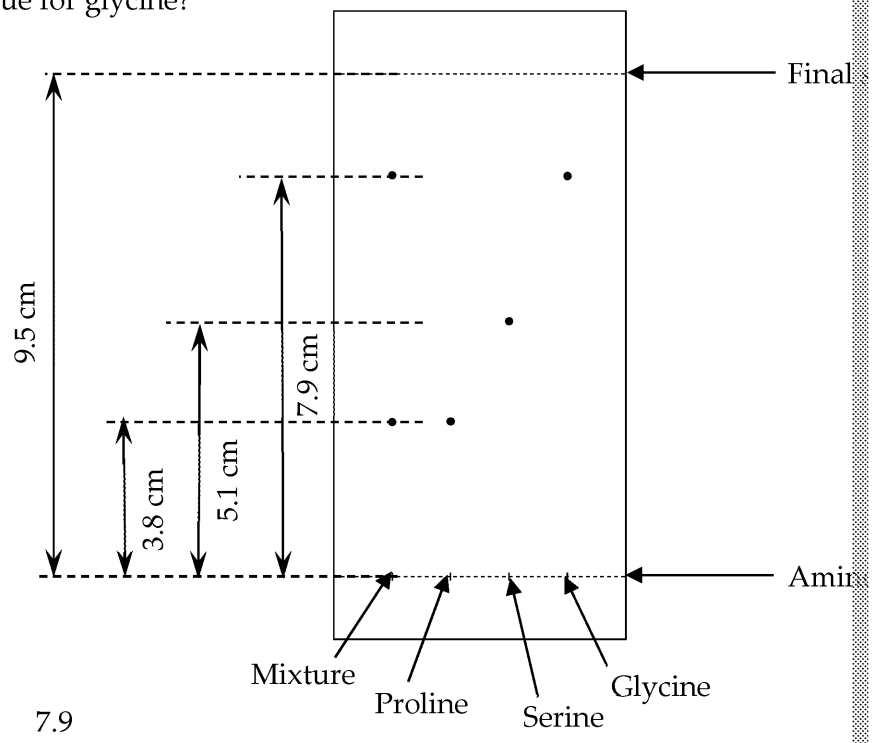
B Compound A has a greater affinity for silica than compound B.

C Compound A is more soluble in the propanone than compound

D Compound A is more volatile than compound B.

[Ques

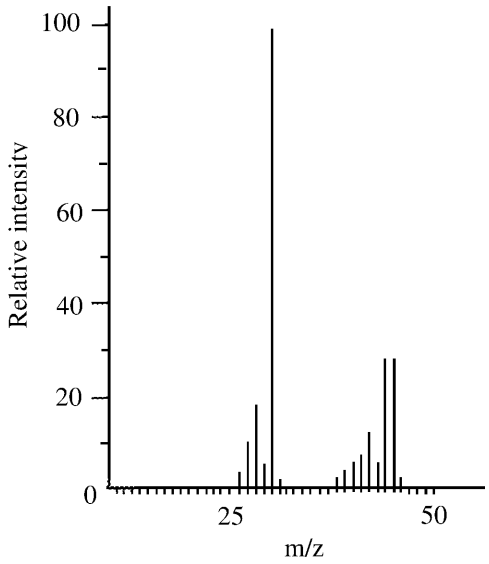
6 The diagram below shows a TLC chromatogram run on a number of value for glycine?



A 7.9
B 1.2
C 0.54
D 0.83

7. What is the main criterion to consider when using mass spectrometry
A Sample composition
B Relative mass of atoms
C Concentration of elements in the sample
D Sample properties

8. The mass spectrum shown is of a hydrocarbon. What is the relative compound, and which one is the base peak?



A Molecular weight: 25, base peak: 30
B Molecular weight: 30, base peak: 45
C Molecular weight: 45, base peak: 30
D Molecular weight: 44, base peak: 30

Section A Quick Answers

Topic 1: Equilibrium II

1. C
2. A
3. D
4. C
5. B
6. D
7. C

Topic 2: Acid-Base Equilibria

1. D
2. B
3. A
4. C
5. D
6. A
7. D
8. D
9. B
10. A
11. D
12. A
13. B

Topic 3: Energetics II

1. C
2. A
3. B
4. D
5. A
6. D
7. A
8. B
9. A
10. B

Topic 4: Redox II

1. C
2. B
3. B
4. A
5. B
6. B
7. D
8. A
9. C
10. D

Topic 5: Transition Metals

1. A
2. B
3. B
4. C
5. D
6. A
7. D
8. A
9. D
10. B
11. A
12. D
13. B
14. C
15. C
16. B
17. B

Topic 6: Kinetics II

1. B
2. C
3. B
4. A
5. B
6. D

Topic 7: Organic C

1. C
2. B
3. D
4. B
5. D
6. C
7. B

Topic 8: Organic C

1. B
2. D
3. A
4. D
5. A
6. D

Topic 9: Modern A

1. A
2. B
3. A
4. D

Section A Full Answers

Topic 1: Equilibrium II

Question 1			
A	×	Not all statements are true	Statement 2 is w pressures = tota
B	×	Statement 2 is not correct	
C	✓		
D	×	Statement 3 is correct, but so is statement 1	
Question 2			
A	✓	Correct (endothermic reaction)	
B	×	This would move the position of equilibrium left	The reverse re favoured by lo
C	×	This would have no effect on the position of equilibrium	There is the sa either side of t
D	×	This would have no effect on the position of equilibrium	There is the sa either side of t
Question 3			
A	×	Wrong partial pressure for PCl_5	The sum of the total pressure
B	×	All partial pressures are wrong	Equilibrium d products are i
C	×	All partial pressures are wrong	These are the r multiplied by partial pressur
D	✓	All partial pressures are correct	Mole fraction I Partial pressur 25.50 kPa Mole fraction c Partial pressur 0.3750 × 102.0
Question 4			
A	×	There are two types of error	The fraction is products/react omitted
B	×	Powers are missing	The fraction co products/react been raised to
C	✓	Correct fraction using the stoichiometric coefficients (numbers from balanced equation) as powers	
D	×	Correct powers have been used, but the fraction is wrong	The fraction is products/react

Question 5			
A	×	Wrong value	The square roo
B	✓	Since $K_p = \frac{(p_{NO_2})^2}{p_{N_2O_4}}$ then $p_{NO_2} = \sqrt{K_p \, x \, p_{N_2O_4}}$ = 198 kPa	
C	×	Wrong value	The expressior down'
D	×	Wrong value	The expressior down', and sq
Question 6			
A	×	One part of the description is wrong	A catalyst will reverse reactio achieved faster
B	×	One part of the description is wrong	A catalyst does of equilibrium
C	×	All of the description is wrong	A catalyst will reverse reactio achieved faster position of equ
D	✓	Correct	
Question 7			
A	×	Not all statements are correct	It is a common K_p is affected b position of this right as pressu of K_p would no
B	×	Not all statements are correct	Catalysts do no since they affe reverse reactio
C	✓	Only temperature affects the value of equilibrium constants	
D	×	The effect of temperature is incorrect	This is an exot -ve) so high ter

Topic 2: Acid-Base Equilibria

Question 1			
A	×	Statement 1 is wrong	Brønsted–Lowr
B	×	Statement 1 is wrong. Statement 2 is wrong.	Ammonia is a B
C	×	Statement 2 is wrong. Statement 3 is wrong.	Brønsted–Lowr **acceptors**, not s
D	✓	No statements are correct (see above)	
Question 2			
A	×	This is an acid–base equilibrium	A proton (H^+ io H_3PO_4 to H_2O
B	✓	This is not an acid–base equilibrium because no protons (H^+ ions)	
C	×	This is an acid–base equilibrium	A proton (H^+ io H_2SO_4 to OH^-
D	×	This is an acid–base equilibrium	A proton (H^+ io HCl to O^{2-}
Question 3			
A	✓	Since $K_a = [H^+][C_6H_5O^-]/[C_6H_5OH]$ and $[H^+] = [C_6H_5O^-]$	
B	×	Equation contains wrong powers	$[H^+]$ should be s
C	×	Equation contains wrong powers and is upside down	A combination
D	×	Equation is upside down	The products (H fraction (the nu
Question 4			
A	×	1 is incorrect	K_w varies with t
B	×	2 is not the only correct statement; 1 is incorrect	K_w varies with t
C	✓	2 and 3 are both correct	
D	×	1 is incorrect	K_w varies with t
Question 5			
A	×	Wrong value	Since the acid is
B	✓	pH = -log(0.2) = 0.7 (to one significant figure)	
C	×	Wrong value and sign	
D	×	Wrong sign	Remember ther equation for cal
Question 6			
A	✓	[acid] = $[H^+] = 10^{-pH} = 10^{-1.3} = 0.050$ mol dm^{-3} (to two significant figu	
B	×	Wrong sign in calculation	$10^{+1.3} = 20$ (to tw
C	×	Wrong formula used	log (1.3) = 0.11 (
D	×	Wrong formula used	10 × 1.3 = 13

Question 7			
A	×	pOH has been calculated	pOH = -log(2
B	×	Sign error	should be pH
C	×	Wrong value	power taken without using
D	✓	$[H^+] = K_w/[OH^-] = 1 \times 10^{-14}/2.5 \times 10^{-3} = 4 \times 10^{-12}$; pH = -log(4 × 10^{-12}	

Question 8			
A	×	Wrong value	[A$^-$] has been not squared)
B	×	Wrong value	[A$^-$] has been squared) and
C	×	Wrong value	This is Ka, no
D	✓	$[H^+] = 10^{-3.79} = 1.62 \times 10^{-4}$ mol dm^{-3}; $K_a = (1.62 \times 10^{-4})^2/(0.250 - 1.62$ pKa = -log $(1.05 \times 10^{-7}) = 6.98$	

Question 9			
A	×	Wrong acid	Ethanoic acid of the curve
B	✓	Correct – the diagram relates to a strong acid / weak base titrati starting pH and a sharp approach to the equivalence point, foll neutralisation, ending in a relatively low pH.	
C	×	Wrong acid and base	
D	×	Wrong base	Sodium hydr and give a sha

Question 10			
A	✓	Since this is a strong acid / weak base titration, the indicator ne values, as this is where the equivalence point will fall	
B	×	Wrong indicator – pH range is unsuitable and will cause an error	This colour ch ammonia (or be added than
C	×	Wrong indicator – pH range is unsuitable and will cause an error	This colour ch ammonia (or than the true
D	×	Wrong indicator – pH range is unsuitable and will cause an error	This colour ch ammonia (or than the true

Question 11			
A	×	Wrong value	This is pKa n
B	×	Wrong value	This is the vo neutralisatio
C	×	Wrong value	Ka has been c
D	✓	Correct value – pKa = pH at half neutralisation and $K_a = 10^{-pKa}$	

Question 12			
A	✓	This mixture is a weak acid plus a salt of that acid, and, as such, w as the weak acid is in excess	
B	×	2 is not a buffer solution	Sulfuric acid i
C	×	Neither 2 nor 3 is a buffer	3 will not form different acid
D	×	There is one mixture that will form a buffer	

Question 13			
A	×	Wrong value	Wrong formu [acid]/[salt])
B	✓	$[H^+] = K_a \times [acid]/[salt] = 6.46 \times 10^{-5} \times 0.50 = 3.23 \times 10^{-5}$. pH = -log(decimal places.	
C	×	Wrong value	Concentration used in the ca
D	×	Wrong value	Wrong formu

Topic 3: Energetics II

Question 1			
A	✗	Wrong use of gas phase and of molar quantity	
B	✗	Wrong use of gas phase	The ions, not t gas phase. Th under standar
C	✓	Correct definition – energy is measured per mole of compound and energy released in *forming* an ionic lattice	
D	✗	Wrong use of molar quantity	The term is de formed
Question 2			
A	✓	Correct: one mole of gaseous atoms is formed	
B	✗	This is not evaporation	
C	✗	Elements don't have an enthalpy of formation	
D	✗	Bond enthalpies apply to covalent bonds	
Question 3			
A	✗		Wrong sign or halve $\Delta H_{dis}^{\ominus}$(F
B	✓	$\Delta H^{\ominus}_{LAT\ (formation)}(CsF) = -\Delta H_{EA1}^{\ominus}(F) - \Delta H_{IE1}^{\ominus}(Cs) - \frac{1}{2}$ $\Delta H_{dis}^{\ominus}(F_2) - A + \Delta H_f^{\ominus}(CsF)$ $\Delta H^{\ominus}_{LAT\ (formation)}(CsF) = 328 - 376 - \frac{1}{2} \times 79 - 77 - 554$	
C	✗		Didn't halve Δ
D	✗		Wrong sign or
Question 4			
A	✗	Sign error	You need to d bromide ions, for calcium ior
B	✗	Sign error	Need to use th formation in tl
C	✗	Wrong value	There are **two**
D	✓	$\Delta_{Sol}H(CaBr_2) = -1650 + (2 \times -337) + 2176 = -148\ kJ\ mol^{-1}$	
Question 5			
A	✓	This has the largest difference between experimental and calculated greatest covalent character (i.e. least perfect ionic lattice)	
B	✗	Wrong compound	There is one w calculated and values of lattic
C	✗	Wrong compound	
D	✗	Wrong compound	

Question 6			
A	✗	Wrong equation	Na should lose
B	✗	Wrong states	Ionisation is d
C	✗	Wrong equation and states	A combination
D	✓	A gas-phase Na atom loses one electron to form an ion with a positi	
Question 7			
A	✓	The solid state represents a lower state of entropy than the aqueous gas phase	
B	✗	Wrong order	A gas will alwa
C	✗	Wrong order	Solids have the
D	✗	Wrong order	Solids are lowe
Question 8			
A	✗	Wrong value	There are two n
B	✓	$\Delta S = S_{products} - S_{reactants} = (2 \times 186.8) - (130.6 + 223.0) = 20.0$	
C	✗	Wrong sign	$S_{products} - S_{reactants}$
D	✗	Wrong value	A combination
Question 9			
A	✓	ΔH is positive, and as T increases ΔG will become more negative if	
B	✗	Not true	If ΔH is positive positive at all te will not be feasi
C	✗	Not true	If ΔH is negativ become more n
D	✗	Not true	If ΔH is negativ negative at all te will be feasible
Question 10			
A	✗	Units not converted properly	108 kJ mol^{-1} = 1
B	✓	Reaction becomes feasible as $\Delta G = 0$; thus $0 = \Delta H - T\Delta S$ or $T = \Delta H/\Delta S$	
C	✗	Equation wrongly rearranged	Should be T = Δ
D	✗	Units not converted properly and equation wrongly rearranged	A combination

Topic 4: Redox II

Question 1			
A	×	Half-equation 2 does not follow IUPAC convention	Electrode half-equa as reductions
B	×	Half-equation 1 is correct but 2 does not follow IUPAC convention	Electrode half-equa as reductions
C	✓	Half-equations 1 and 3 are correctly written as reductions	
D	×	Half-equations 1 and 3 are correct but 2 does not follow IUPAC convention	Electrode half-equa as reductions
Question 2			
A	×	Correct symbols but not in the correct order	Cl^- and Cl_2 are in th representation shou they would be seen Cl_2 is would be red
B	✓	All symbols correct and in the correct order. The left-hand side sh the right-hand side should represent reduction.	
C	×	One symbol is not correct	Salt bridges are sho Also, Cl^- and Cl_2 ar
D	×	There is an unnecessary symbol	There is no Fe^{3+} sho
Question 3			
A	×	Not the only correct answer	Concentration also
B	✓	Correct – pressure does not affect this particular electrode potentia	
C	×	One incorrect answer	Pressure does not a potential as no gase
D	×	One incorrect answer	Pressure does not a potential as no gase
Question 4			
A	✓	The cell potential would be 0.80 V – -0.76 V = 1.56 V. As this is the represents the most favourable potential.	
B	×	The cell potential would be 0.80 V – 0.00 V = 0.80 V	
C	×	The cell potential would be -0.76 V – 0.80 V = -1.56 V	
D	×	The cell potential would be 0.00 V – -0.76 V = 0.76 V	
Question 5			
A	×	Wrong half-cell	The cell involves C
B	✓	Since the standard hydrogen electrode has an electrode potential c V = 0.34 V	
C	×	Wrong half-cell and wrong sign	The cell involves C
D	×	Wrong sign	

Question 6			
A	×	Hydrogen gas is at standard pressure	Bubbling into an ope 1 atm, which is stand
B	✓	Standard temperature is 298 K (25 °C), not 273 K (0 °C)	
C	×	Concentrations of the two solutions of copper ions is still considered standard conditions (even though they are not 1 mol dm^{-3})	For a single solution 1 mol dm^{-3}, but for t just need to be equal
D	×	Hydrogen ion concentration is standard	1 mol dm^{-3} is the star
Question 7			
A	×	One equation is wrong	Although the cell is oxidised and Fe^{2+} rec negative value so the
B	×	Both equations are wrong	This is a combinatio
C	×	One equation is wrong	Mg is oxidised by A the EMF of the cell is
D	✓	Correct – both equations show the reactions in the correct directio	
Question 8			
A	✓	Yes – when this is added to the anode half-equation, it forms the sa given in the question	
B	×	The balancing is wrong	Although the half-eq does not add to the a overall equation (the for instance)
C	×	Mass balance is wrong	There are more O an the right of this equa
D	×	Charge balance is wrong	There is an overall c with 0 on the right
Question 9			
A	×	Wrong cell type	This is not a fuel cell the cell
B	×	Wrong cell type	This cell can be recha
C	✓	The lithium cell is a common type of rechargeable cell	
D	×	Wrong cell type	This cell can be recha term for non-recharg
Question 10			
A	×	Wrong explanation	It is an external, not that generates the el
B	×	Wrong equations	The equations are the
C	×	Wrong equations and explanation	A combination of the
D	✓	The equations and the explanation are all correct	

Topic 5: Transition Metals

Question 1			
A	✓	This is correct even though the 4s level is not full – it is the most s	
B	×	Not a transition metal	Transition metal This is the electr which has a full oxidation states.
C	×	Wrong inner shell configuration	The core electron transition metals
D	×	Wrong inner shell configuration and not a transition metal	A combination o
Question 2			
A	×	One error	CO forms coord
B	✓	Everything is correct	
C	×	One error	The iron in haem not III
D	×	One error	CO does not for molecule
Question 3			
A	×	Incorrect	There are exactly broken as forme
B	✓	Correct – it is the increase in entropy that drives the reaction forw	
C	×	Incorrect logic	Endothermic rea form *less* stable p are more likely t
D	×	Incorrect	$[Ni(H_2O)_6]^{2+}$ is sta
Question 4			
A	×	Wrong shape	It is a square pla
B	×	Not the only correct answer	There is cis-trans
C	✓	It is a fourfold coordination complex with cis-trans isomerism	
D	×	Wrong shape	It is a square pla
Question 5			
A	×	Wrong isomerism type	You can't have t
B	×	Wrong isomerism type	Cis-trans and E/Z
C	×	Wrong isomerism type	You can't have t
D	✓	Correct – the two structures are non-superimposable mirror imag	

Question 6			
A	✓	All six water ligands are replaced by four chloride ion ligands	
B	×	Incorrect description	It is a complete s are replaced
C	×	Incorrect description	Both water and c
D	×	Incorrect description	Although the lig incomplete subs
Question 7			
A	×	Not the only correct answer	All three are typ
B	×	Not complete	All three are typ
C	×	Not complete	All three are typ
D	✓	Correct and complete	
Question 8			
A	✓	As it is in the same phase as the reactants, $FeCl_2$ is a homogeneous oxidation state allows it to catalyse the redox reaction.	
B	×	Wrong type of catalyst	As it is in the sa is a homogeneou
C	×	Wrong mechanism of catalysis	$FeCl_2$ catalyses t oxidation state
D	×	Wrong type of catalyst	$FeCl_2$ is a homog
Question 9			
A	×	Incomplete	This is not the o
B	×	Incomplete	These are not th
C	×	Incomplete	These are not th
D	✓	Correct	
Question 10			
A	×	Wrong ion	$[VO(H_2O)_5]^{2+}$ has will reduce this state V will not l
B	✓	Correct	
C	×	Wrong reaction	$KMnO_4$ will oxi oxidation state I oxidation states
D	×	Wrong reaction	$KMnO_4$ will not its highest oxida
Question 11			
A	✓	Correct	
B	×	Second equation is wrong	Since V_2O_5 is no acting as a catal
C	×	Wrong process	V_2O_5 is not a cat
D	×	Wrong process and not catalysis	The formation o and this does no

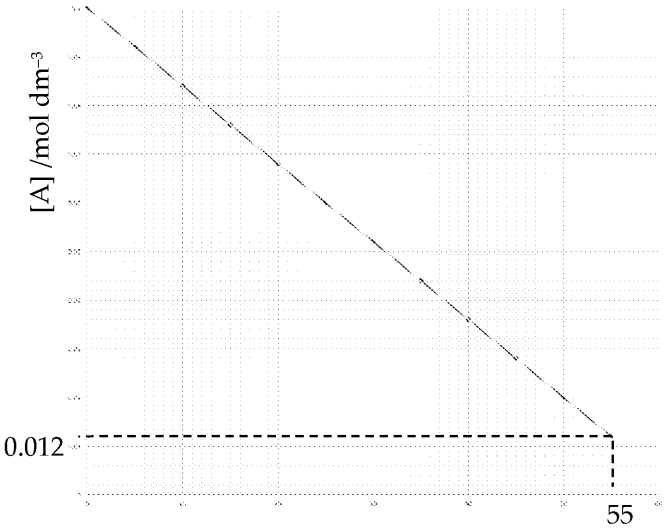
Question 12			
A	×	Does not show catalysis	This is the corr show Mn^{2+} acti
B	×	Not a complete sequence	These two equa being used up
C	×	Does not show *auto*catalysis	Although equa as a catalyst, to *auto*catalysis it formation of th reaction (equat
D	✓	Correct	
Question 13			
A	×	Observation for Fe^{3+} is wrong	$Fe(OH)_3$ does n
B	✓	Correct observation for both Fe^{3+} and Al^{3+}	
C	×	Observation for Al^{3+} is wrong	$Al(OH)_3$ reacts $[Al(OH)_6]^{3-}$, wh
D	×	Observation for both is wrong	$Fe(OH)_3$ does n but $Al(OH)_3$ d
Question 14			
A	×	Wrong formulae for reactant and product complex ions	Cu^{2+} forms an i four, and with
B	×	Wrong formulae	Cu^{2+} forms an i
C	✓	All formulae correct – all six water ligands replaced by three DM	
D	×	Wrong equation	All six monode replaced by thr
Question 15			
A	×	Partially incorrect	Although d-ele energy within absorption, not
B	×	Partially incorrect	Although light d-electrons mo within the d-su different subsh
C	✓	Correct	
D	×	Incorrect	d-electrons mo within the d-su

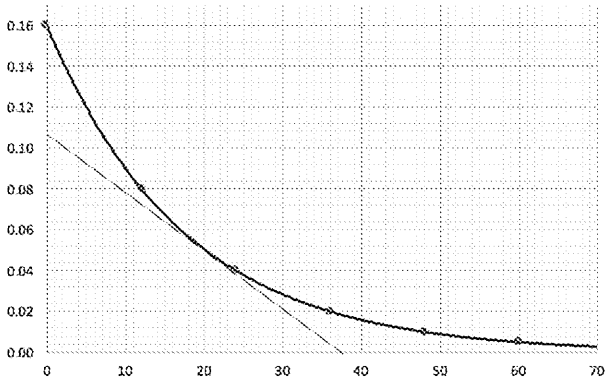
Question 16			
A	×	Value is not a concentration	The number of r correctly calcula concentration (n – 20 cm^3 or 0.02(
B	✓	Calculation is correct: (17.5/1000) × 0.0185 = 3.2375×10^{-4} moles of dichromate reacting ratio = 1:6 so $3.2375 \times 10^{-4} \times 6 = 1.9425 \times 10^{-3}$ moles of Fe pr concentration = $1.9425 \times 10^{-3}/(20.0/1000) = 9.7125 \times 10^{-2} = 9.71 \times 10^{-2}$	
C	×	Wrong concentration	The reacting rati account
D	×	Wrong concentration	The concentratio been scaled up b different volume been accounted

Question 17			
A	×	Wrong conclusion from correct premise	Although Fe(III) Fe(II), this does for iron(III) com
B	✓	Correct	
C	×	Explanation is wrong	Iron complexes a ions rather than
D	×	Explanation is wrong	Iron(II) and iron release OH^- ions cause solutions t

Topic 6: Kinetics II

Question 1			
A	×	Rate equation has been written to include concentration of each reactant as a term	It is possible fo rate equation ([H+] is zero ord the table of dat
B	✓	Correct reactants and terms are raised to correct powers (orders are correct) – first order in both cases	You can tell tha respect to I^- by table of data – the rate change halves). In the and 3 shows th factor of 4, so c first order.
C	×	Rate equation has been written to include the concentration of each reactant as a term, and the stoichiometric coefficients (balancing numbers) have been used as powers	This is an easy the correct way expression for to form a rate e
D	×	Correct reactants included in the rate equation, but the power is wrong (wrong order) for H_2O_2	The data has be reactants affect correctly used that the rate **qu** concentration c – but it is impo the $[H_2O_2]$ also
Question 2			
A	×	$[H_2]$ hasn't been squared	This is the resu
B	×	Equation rearranged wrongly (multiplication instead of division)	This is the resu
C	✓	Rearranging equation: $\mathbf{k = Rate/[NO][H_2]^2}$ Substituting values from table: $k = 1.20/(0.0460 \times (0.0130)^2) = 1.20/7.77 \times 10^{-6}$ $= 1.54 \times 10^5$	
D	×	Equation rearranged wrongly (multiplication instead of division) and $[H_2]$ not squared	This is a comb incorrect answ
Question 3			
A	×	Rate increases linearly with [A]	This linear rela first-order reac concentration
B	✓	A horizontal line represents zero order in rate–concentration graphs	
C	×	Rate decreases with [A]	For zero order effect upon rat
D	×	Rate increases (non-linearly) with [A]	This shape of g order reactions concentration

Question 4			
A	✓	Since the time (very nearly) quarters (and so the rate increases fourfold) as the [HCl] doubles, this is a second-order relationship. Time halves (and rate doubles) as $[Na_2S_2O_3]$ doubles, indicating a first-order relationship.	
B	×	Wrong order for $Na_2S_2O_3$	
C	×	Wrong order for HCl	
D	×	Wrong order for both	
Question 5			
A	×	Error in calculating gradient (Δy measured as 0 – 0.1 instead of 0.012 – 0.1). Also, wrong sign (k cannot be negative).	The line does (i.e. [A] = 0). is negative (s k must be a p
B	✓	 Gradient of line = ((0.012 – 0.1) mol dm^{-3})/((55 – 0) s) = -0.088/55 = k = – gradient = 1.6×10^{-3} mol dm^{-3} s^{-1}	
C	×	Wrong sign (k cannot be negative) and units	k must be a p must include
D	×	Error in calculating gradient. Also, wrong units.	Gradient cal instead of Δy the units of c
Question 6			
A	×	This is the reciprocal of the correct answer rounded to two significant figures	Gradient has Δx/Δy
B	×	This is (0.16 – 0.050) mol dm^{-3}/20 s $= 5.5 \times 10^{-3}$ mol dm^{-3} s^{-1}	Rather than to the curve, calculate the from the gra **graph were a** **for curves.**

Question 6 (continued)			
C	×	This is 1/20	A misunderst… a given time … proportional … come from re… coincidence …
D	✓	 Gradient of tangent to the curve at t = 20 s (see picture) = 0.105 mol … (Actual value may vary slightly depending on how tangent is dr… the same when rounded to two significant figures.)	
Question 7			
A	×	Technique 1 will work since an acid (HCl) is produced	BUT it is not … be used
B	×	This will work since a gas (N_2) is produced	BUT it is not … be used
C	×	This will work since the reaction is exothermic (temperature will rise as reaction proceeds)	BUT it is not … be used
D	✓	All of the techniques could be used	
Question 8			
A	✓	The rate measured up to the point where the sodium thiosulfate … produced causes a colour change) is an approximation of the ini… close to the true initial rate so long as the reaction has not progre…	
B	×	Second reason is incorrect	For an accur… important th… very far whe…
C	×	First reason is incorrect	None of the … (The *product*… starch that is …
D	×	Both reasons are incorrect	See B and C …
Question 9			
A	×	Wrong powers	The orders (p… correspond t…
B	×	Wrong formulae	The orders (p… molecularity …
C	✓	Correct – the orders match the molecularity of the slow (rate-det…	
D	×	Wrong formulae	Only reactan… equations

Question 10			
A	×	Although k does increase, it is not a linear relationship	Failure to no… is exponentia…
B	×	k will increase, not decrease, and it is not a linear relationship	Could be an … sign in -E_a/R…
C	✓	As T increases the value of the fraction E_a/RT becomes smaller, so -E_a/RT becomes less negative – hence $e^{-E_a/RT}$ overall increases exponentially	
D	×	k will increase, not decrease	Could be an … sign in -E_a/R…
Question 11			
A	✓	Comparing ln k = -E_a/RT + ln A to y = mx + c shows that the grad… -E_a/R. R is a constant.	
B	×	This is the wrong graph to plot	A mistake in … plotted on th…
C	×	This would give -E_a, not E_a	A sign error: … cannot be ne…
D	×	This is the wrong graph to plot	A mistake in … plotted on th…

Question 1			
A	×	Carbons 1 and 3 have four different groups attached, so are chiral	
B	×	Carbon 2 has two identical groups, so is not chiral	
C	✓	Carbons 1 and 3 have four different groups attached, so are chiral	
D	×	Carbon 2 has two identical groups, so is not chiral	
Question 2			
A	×	This has just been rotated	
B	✓	This is a rotated mirror image (you can tell because two groups are two have been swapped)	
C	×	This has just been rotated	
D	×	This has just been rotated	
Question 3			
A	×	The number of chiral centres is not relevant	
B	×	The amounts of each enantiomer must be equal	
C	×	A racemic mixture only needs one kind of chiral compound but equ	
D	✓	This is the correct definition	
Question 4			
A	×	One wrong reaction	Propanone canno
B	✓	Both primary alcohols and aldehydes can be oxidised to carboxylic	
C	×	Wrong reaction	Propanone canno
D	×	One wrong reaction	Propanone canno
Question 5			
A	×	Will not tell propanone and propanal apart	KCN will react w
B	×	Will not tell propanone and propanal apart	Na_2CO_3 will not
C	×	Will not tell propanone and propanal apart	$NaBH_4$ will react
D	✓	This is Tollens' reagent, which will produce a silver mirror only wit	
Question 6			
A	×	Wrong functional group	Addition of HCN
B	×	Wrong functional group and too few carbons	Addition of HCN increases the nur one
C	✓	Correct – a three-carbon hydroxynitrile forms	
D	×	Too few carbons	Addition of HCN in the product by
Question 7			
A	×	Incorrect	There is only one that can be attack
B	✓	Correct	
C	×	Incorrect	A rearrangement
D	×	Incorrect conclusion	The C=O bond ca no atoms connec

Question 8			
A	✓	Correct – the section from an alcohol has three carbons, and the ca	
B	×	This is propyl pentanoate	
C	×	This is butyl butanoate	
D	×	This is butyl propanoate	
Question 9			
A	✓	Hydrolysis of an ester with an alkali forms a salt. The carbonyl pa so the salt will have two carbons (and the alcohol, one).	
B	×	Incorrect products	Wrong alcohol
C	×	Incorrect products	Hydrolysis witl
D	×	Incorrect products	Hydrolysis witl
Question 10			
A	×	This arrow is correct	When the nucle carbonyl carbo oxygen (the pi l
B	×	This arrow is correct	The double bon forms again
C	✓	Nitrogen does not leave again	
D	×	This arrow is correct	The C–Cl bond oxygen (the pi l
Question 11			
A	×	Wrong product	This would be n an excess of am
B	×	Wrong product	
C	×	Wrong product	This would be n acid anhydride
D	✓	Correct	Ammonia and a amide
Question 12			
A	✓	All three are correct	
B	×	1 and 2 reversed	Silver mirror is
C	×	2 and 3 reversed	Carboxylic acid
D	×	All three are wrong	See above
Question 13			
A	×	Not an error	Water should fl
B	✓	Correct – a thermometer in a thermometer pocket should be in the there to seal it, the vapours will escape from here rather than going	
C	×	Not an error	This should not could build up
D	×	Not an error	This is the corre condenser is us

Topic 8: Organic Chemistry III

Question 1			
A	×	Error in statement	The enthalpy of
B	✓	This indicates that benzene is more stable than if it had three localised C	
C	×	Error in statement	The enthalpy of
D	×	Error in statement	Delocalisation *r* during hydroge

Question 2			
A	×	Wrong reagent	This would alky
B	×	Wrong reagent	This is a combin
C	×	Wrong reagent	Sulfuric acid ca enable the reacti
D	✓	This is the Friedel–Crafts acylation reaction with $AlCl_3$ as a halogen carri	

Question 3			
A	✓	Correct – without only partial delocalisation, products of addition reacti	
B	×	Wrong reason	Small atoms wo
C	×	Irrelevant	The shape of the whether additio
D	×	Untrue	Electrophiles ur e.g. to alkenes

Question 4			
A	×	Wrong products	The nitrating ele
B	×	Charges missing	The charges do n
C	×	Wrong products	$H_2NO_3^+$ may be final product
D	✓	NO_2^+ is the correct electrophile – and the equation is correctly balanced	

Question 5		
A	✓	
B	×	$COCH_3$ should not be negative, as it is an electrophile
C	×	$COCH_3$ should not donate electrons into the ring, as the ring is electron dense
D	×	As above, $COCH_3$ should not donate electrons into the electron-dense ring

Question 6		
A	×	Methylamine is more basic than ammonia
B	×	Ammonia is more basic than phenylamine
C	×	Ammonia and methylamine are more basic than phenylamine
D	✓	Correct order

Question 7			
A	×	One arrow wrong	Electrons travel towards, not awa
B	×	One arrow wrong	Electrons travel away from, not to
C	✓	Correct	
D	×	One arrow in wrong sequence	The C=O pi bond breaks and then

Question 8			
A	×	Not protonated	Under acidic conditions, the NH_2 form NH_3^+
B	×	Deprotonated	The OH group would not lose an – this would require alkaline conc
C	×	Zwitterion	The zwitterion only exists when th acid – not in strongly acidic condi
D	✓	At very low pH, the NH_2 group would react with H^+ ions to form NH_3^+ ar	

Question 9			
A	×	Not all amino acids identified	Alanine, $NH_2CH(CH_3)COOH$, is a
B	✓	Correct	
C	×	Not all of these are amino acids	The last molecule does not have a
D	×	Not all amino acids identified	Glycine, NH_2CH_2COOH, is also p

Question 10			
A	✓	Correct	
B	×	Incorrect	Hydrogen bonds are responsible f and tertiary structures
C	×	Incorrect	Hydrogen bonds, not sulfur–sulfu protein in its secondary structure
D	×	Incorrect	Sulfur–sulfur bonds are not respo secondary structure

Question 11			
A	✓	Step 1 increases the chain length by turning chloroethane into propan a primary amine.	
B	×	Fails to increase the chain length	This would produce ethylamine
C	×	Wrong functional group produced	This would produce propanoic ac
D	×	Reaction would fail entirely	The ammonia would be lost as a g

Question 12			
A	✓	Correct reagents	Step 1 – CN^- acts as a nucleophile, on the carbon in the aldehyde Step 2 – HCl performs acid hydro carboxylic acid group (NH_4^+ is a s
B	×	First step works but second step does not	Step 2 – oxidation by $K_2Cr_2O_7$ can
C	×	Neither step works	Step 1 – $NaBH_4$ cannot lengthen th Step 2 – a secondary alcohol canno with an alcohol group
D	×	Neither step works	Step 1 – oxidation cannot lengthen Step 2 – OH cannot substitute the have a positive dipole, i.e. OH^- ca

Topic 9: Modern Analytical Techniqu

Question 1			
A	✓	Correct	
B	×	Incorrect	The splitting pattern f actual number of H at
C	×	Incorrect	The splitting pattern f the number of neighb
D	×	Incorrect	Both signals will be sp

Question 2			
A	×	Too few	There are two proton
B	✓	There is one signal for the proton on the OH group and one more f CH_3 groups	
C	×	Too many	The three CH_3 groups environment
D	×	Too many	The three CH_3 groups environment

Question 3			
A	✓	This is the only structure with just two different chemical environ the spectrum	
B	×	Too many chemical environments	This structure has thr so the spectrum woul
C	×	Too many chemical environments	This structure has thr so the spectrum woul
D	×	Too many chemical environments	This structure has thr so the spectrum woul

Question 4			
A	×	Too few compounds	There are five peaks
B	×	One wrong compound	There is no peak at 1.
C	×	Too many compounds	There is no peak at 0.
D	✓	Same number of compounds as peaks; all retention times are corr	

Question 5			
A	×	Wrong reason	In this type of chrom molecules that affects through the column
B	×	Reverse reasoning	High affinity for the substance to pass thr
C	✓	Correct	
D	×	Wrong reason	In chromatography, v speed at which the su the column

Question 6			
A	×	Wrong value	This is simply the l
B	×	Wrong value	The formula for cal (i.e. 9.5/7.9 instead
C	×	Wrong amino acid	The calculation is c acid (serine)
D	✓	Correct	
Question 7			
A	×	Incorrect	Composition is de analysis method
B	✓	Correct	
C	×	Incorrect	A mass spectromete sample under inves according to their s and then the relativ
D	×	Incorrect	
Question 8			
A	×	Incorrect	There is no peak at
B	×	Incorrect	Molecular weight i peak is at 30
C	✓	Molecular ion (M^+) represents the intact molecule which has th molecule (M); the highest peak is the molecular ion, and the ba the spectrum) represents the most stable fragment	
D	×	Incorrect	44 is not the molec

Topic 1: Equilibrium II

1. This question is about the equilibrium between dinitrogen tetroxide a
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$.

The expression for K_p for this equilibrium is: $K_p = \frac{(P_{NO_2})^2}{P_{N_2O_4}}$

Which of the following statements relating to this gas-phase chemica
explains how the equilibrium constant, K_p, controls the position of eq
pressure is increased?

A As the total pressure increases, the value of K_p initially rises. Th
increasing the partial pressure of N_2O_4 and decreasing the partia
the value of K_p returns to its original value.

B As the total pressure increases, the value of K_p initially falls. Th
increasing the partial pressure of NO_2 and decreasing the partia
the value of K_p returns to its original value.

C As the total pressure increases, the equilibrium shifts left, increa
of N_2O_4 and decreasing the partial pressure of NO_2. The value o

D As the total pressure increases, the equilibrium shifts right, incr
pressure of NO_2 and decreasing the partial pressure of N_2O_4. Th
therefore increases.

2. Nitrogen and oxygen form an equilibrium mixture with nitrogen mo

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

Under certain conditions, the value of the equilibrium constant, K_p, is
If an equilibrium is established under these conditions, in which it is
partial pressure of both N_2 and O_2 is 28 kPa, what is the equilibrium p

A 882 kPa

B 697 kPa

C 26.4 kPa

D 29.7 kPa

3. The following equilibrium is set up in the gas phase:

$$C_6H_6(g) + 3H_2(g) \rightleftharpoons C_6H_{12}(g) \quad \Delta H = -208 \text{ kJ m}$$

Which of the following would increase the amount of cyclohexane, C_6H

1: A decrease in pressure at constant temperature
2: A decrease in temperature at constant pressure
3: Addition of a nickel catalyst to the mixture

A Only 1

B Only 2

C Only 3

D 1, 2 and 3

4. Which is the correct expression for K_p for the following reaction?

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

A $K_p = \dfrac{(p_{SO_3})^2}{(p_{SO_2})^2 p_{O_2}}$ ☐

B $K_p = \dfrac{p_{SO_3}}{p_{SO_2} p_{O_2}}$ ☐

C $K_p = \dfrac{p_{2SO_2} p$

D $K_p = \dfrac{(p_{SO_2})}{(p_{SO}$

5. In the following gas phase equilibrium, $K_p = 3.94\ kPa^{-1}$. If the partial
and the partial pressure of H_2O is also 6.70 kPa at equilibrium, what
equilibrium mixture?

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

A 177 kPa
B 184 kPa
C 190 kPa
D 17.3 kPa

6. Which of the following shows the correct units for K_p for the followi

$$2ICl_3(g) \rightleftharpoons I_2(g) + 3Cl_2(g)$$

A Pa
B Pa^{-2}
C Pa^2
D There are no units

7. Changes in conditions can affect chemical equilibria and may cause t
constant to change. Which of the following statements correctly desc
temperature and pressure and the presence of a catalyst affect the fol

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92\ kJ\ mo$$

A K_p will:
- increase with increasing temperature
- increase with increasing pressure
- be unchanged if a catalyst is added

B K_p will:
- decrease with increasing temperature
- increase with increasing pressure
- increase if a catalyst is added

C K_p will:
- increase with increasing temperature
- be unchanged with increasing pressure
- be unchanged if a catalyst is added

D K_p will:
- decrease with increasing temperature
- be unchanged with increasing pressure
- be unchanged if a catalyst is added

Topic 2: Acid-Base Equilibria

1. Which of the following equations are Bronsted–Lowry acid–base equ

   1: $H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$
   2: $CH_3OH + HCl \rightleftharpoons CH_3OH_2^+ + Cl^-$
   3: $C_2H_4 + H_2 \rightleftharpoons C_2H_6$

   A Only 1
   B Only 1 and 2
   C Only 2 and 3
   D 1, 2 and 3

2. What would be the pH of a solution in which the concentration of hyd 1.45 mol dm^{-3}?
   A 0.161
   B 0.372
   C -0.161
   D -0.372

3. Which of the following is not a Brønsted–Lowry acid–base reaction?
   A $H_2 + O_2 \longrightarrow H_2O$
   B $H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + 2H_2O$
   C $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
   D $HNO_3 + NH_3 \longrightarrow NH_4NO_3$

4. Which of the following is the correct mathematical equation for pK_a f
   A $pK_a = [H^+]^2/[HCOOH]$
   B $pK_a = -\log([H^+]/[HCOOH])$
   C $pK_a = -\log([H^+]^2/[HCOOH])$
   D $pK_a = [H^+]/[HCOOH]$

5. Which is the only correct statement?
   A High values of pKa indicate very strong acids.
   B Concentrated solutions of acids with large Ka values will have h
   C Both pH and pKa values are affected by changing the concentrat
   D There are more H^+ ions in a 1 mol dm^{-3} solution of an acid with a 1 mol dm^{-3} solution of an acid with a low Ka value.

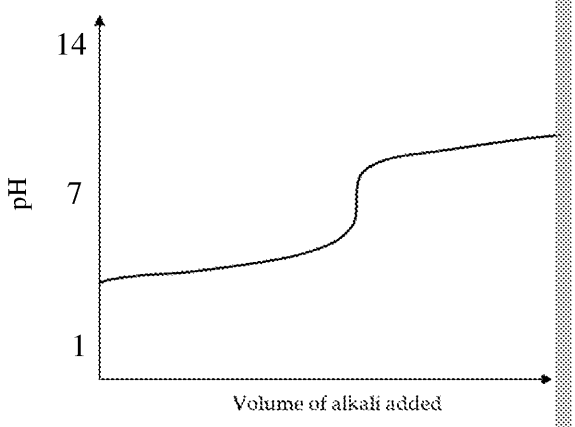
6. What is the pH of a solution of a *strong* acid, HA, with a concentratio
   A 1.3
   B 3.0
   C -1.3
   D -3.0

7. If a solution of a strong *diprotic* acid (i.e. an acid that dissociates to gi
mole of acid molecule) has a pH of 1.0, what is the concentration of t
A 0.10 mol dm^{-3}
B 0.20 mol dm^{-3}
C 0.05 mol dm^{-3}
D 2.0 mol dm^{-3}

8. A solution of potassium hydroxide, KOH, has a pH of 12.3. What is the
A 0.02 mol dm^{-3}
B 0.01 mol dm^{-3}
C 1.7 mol dm^{-3}
D 1.09 mol dm^{-3}

9. A solution of a weak acid, HA, with a concentration of 0.125 mol dm
the pK_a value for this acid?
A 3.42
B 3.83×10^{-4}
C 7.74
D 1.87×10^{-8}

10. The diagram below shows an acid–base titration curve. Which com
could produce this curve?



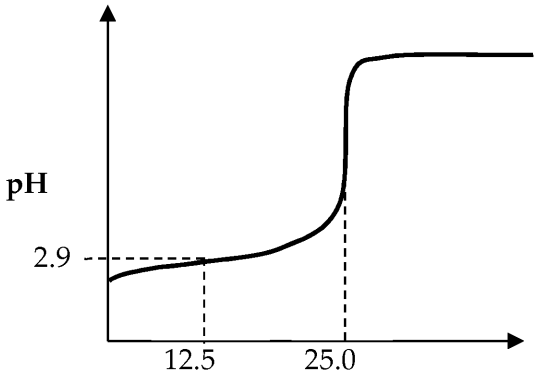
A Ethanoic acid and ammonia
B Sulfuric acid and ammonia
C Ethanoic acid and sodium hydroxide
D Sulfuric acid and sodium hydroxide

11. The table below shows the pH range at which various indicators ch
or indicators would give an accurate result in a titration of ethanoic

Indicator	pH range ov
Indicator 1	
Indicator 2	
Indicator 3	

A Indicator 1 only
B Indicators 1 and 2
C Indicators 2 and 3
D None of the indicators

12. Use the following pH curve to calculate the K_a of the acid involved:



A 2.90
B 12.5
C 794
D 1.26×10^{-3}

13. Which of the following methods could produce a *buffer solution*?

1: A solution of a weak acid mixed with a solution of a strong aci
2: A solution of a weak acid mixed with a solution of a salt of the
3: A solution of a weak acid mixed with a solution of a salt of a st

A Only 1
B Only 2
C Only 3
D 1, 2 and 3

14. A buffer solution made by mixing equal volumes of ethanoic acid a
solutions, both with a concentration of 0.50 mol dm^{-3}, has a pH of 4.
acid dissociation constant, K_a, for ethanoic acid?

A 1.74×10^{-5} mol dm^{-3}
B 5.75×10^{4} mol dm^{-3}
C 6.04×10^{-10} mol dm^{-3}
D 4.76×10^{-5} mol dm^{-3}

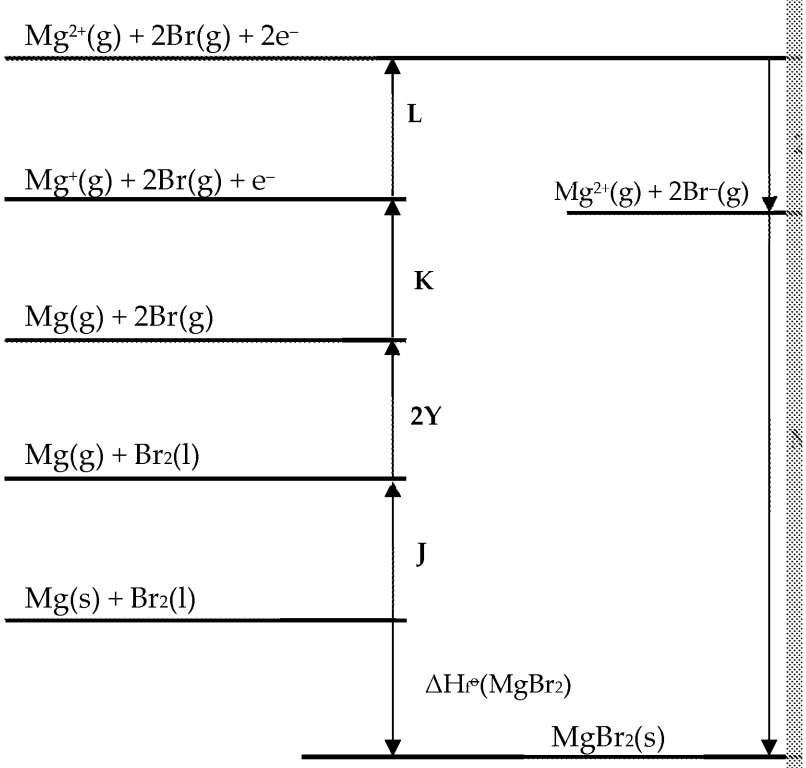
Topic 3: Energetics II

1. Which of the following can correctly define *lattice energy*?

   1: The internal energy of an ionic lattice
   2: The enthalpy of dissociation of an ionic lattice
   3: The enthalpy of formation of an ionic lattice

   A 1 only
   B 1 and 2 only
   C 2 and 3 only
   D 1, 2 and 3

2. Which of the letter expressions corresponds to the enthalpy of atomis



   A 2Y
   B Y
   C 2Z
   D Z

3. Calculate the enthalpy of formation of magnesium bromide using the the data below.

Enthalpy change	Energy (kJ mo
J	+148
Y	+224
K	+738
L	+1451
Z	–325
M	–2440

A +529 kJ mol^{-1}

B +305 kJ mol^{-1}

C -529 kJ mol^{-1}

D -305 kJ mol^{-1}

4. Use the data below to calculate the enthalpy of hydration of ammo

$\Delta_{LE}H$ (NH_4NO_3) = 646 kJ mol^{-1}; $\Delta_{sol}H$ (NH_4NO_3) = 25 kJ mol^{-1}; Δ

A +307 kJ mol^{-1}

B -307 kJ mol^{-1}

C -357 kJ mol^{-1}

D +357 kJ mol^{-1}

5. Use the data below to put the ionic compounds in order from those to those with **least** covalent character.

Compound	Theoretic Lattice Energy /kJ mol^{-1}	E
LiCl	834	
NaCl	910	
NaI	682	
AgCl	864	

A AgCl, NaI, LiCl, NaCl

B NaCl, AgCl, LiCl, NaI

C NaI, LiCl, AgCl, NaCl

D AgCl, LiCl, NaI, NaCl

6. Which of the following equations correctly represents the first elect

A $Cl(g) + e^- \rightarrow Cl^-(g)$

B $Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

C $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

D $Cl_2(g) + e^- \rightarrow Cl^-(g) + Cl(g)$

7. Which of the following is the correct definition for the enthalpy of hy

A The enthalpy change when one mole of gaseous sodium ions dis water

B The enthalpy change when one mole of sodium ions in a solid io one mole of water

C The enthalpy change when one mole of sodium ions in a solid io enough water to form an infinitely dilute solution

D The enthalpy change when one mole of gaseous sodium ions dis form an infinitely dilute solution

8. Which of these reactions involves an increase in entropy?

A $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

B $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

C $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$

D $SiH_4(g) + O_2(g) \rightarrow SiO_2(s) + 2H_2(g)$

9. Calculate the change in entropy of the following reaction, using the d

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

	Molar entropy /J K^{-1} mol^{-1}
$CaCO_3(s)$	92.9
$CaO(s)$	38.3
$CO_2(g)$	214

A -82.8 J K^{-1} mol^{-1}

B +159.4 J K^{-1} mol^{-1}

C -159.4 J K^{-1} mol^{-1}

D +82.8 J K^{-1} mol^{-1}

10. Use the data in the table below to select which of the reactions is/are

Reaction	**Enthalpy change, ΔH /kJ mol^{-1}**	**Entropy c /J K^{-1}**
1. $CaCO_3 \rightarrow CaO + CO_2$	178	1
2. $CaO + H_2O \rightarrow Ca(OH)_2$	-82	-2
3. $NH_4NO_3(s) \rightarrow NH_4NO_3(aq)$	25	1

A Reaction 1 only

B Reactions 1 and 2 only

C Reactions 2 and 3 only

D Reactions 1, 2 and 3

Topic 4: Redox II

1. Which of the following statements is correct according to the IUPAC equations for electrode reactions?

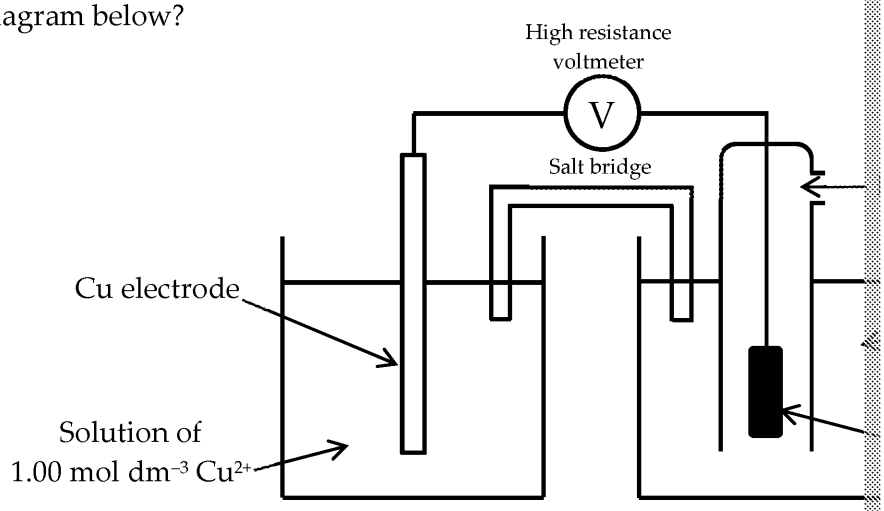
   A Half-equations should show only one electron on the left-hand s

   B Half-equations should show only one electron on the right-hand

   C Half-equations should always be written as reduction processes.

   D Half-equations should always be written as oxidation processes.

2. Which is the correct conventional representation of the electrochemic diagram below?



   A $Pt(s)\,|H_2(g)|H^+(aq)||Cu^{2+}(aq)|Cu(s)$

   B $Cu(s)|Cu^{2+}(aq)|H_2(g)|H^+(aq)|Pt(s)$

   C $Cu(s)|H_2(g)|H^+(aq)||Cu^{2+}(aq)|Pt(s)$

   D $Cu(s)|H_2(g)\,||Cu^{2+}(aq)\,|2H^+(aq)|Pt(s)$

3. Which of the following can affect the value of the electrode potential

   $Pt(s)|Cl_2(g)|Cl^-(aq)||$

   1: The temperature of the room
   2: The pressure of the chlorine gas
   3: The concentration of the chloride ions

   A Only 1

   B Only 1 and 3

   C Only 2 and 3

   D 1, 2 and 3

4. Use the data given below to select which of the combinations of reac potential of +1.55 V.

Half-cell					Standard electro
$Pb^{2+}(aq)$	+	$2e^-$	⇌	Pb(s)	-(
$Ag^+(aq)$	+	e^-	⇌	Ag(s)	(
$Al^{3+}(aq)$	+	$3e^-$	⇌	Al(s)	-1

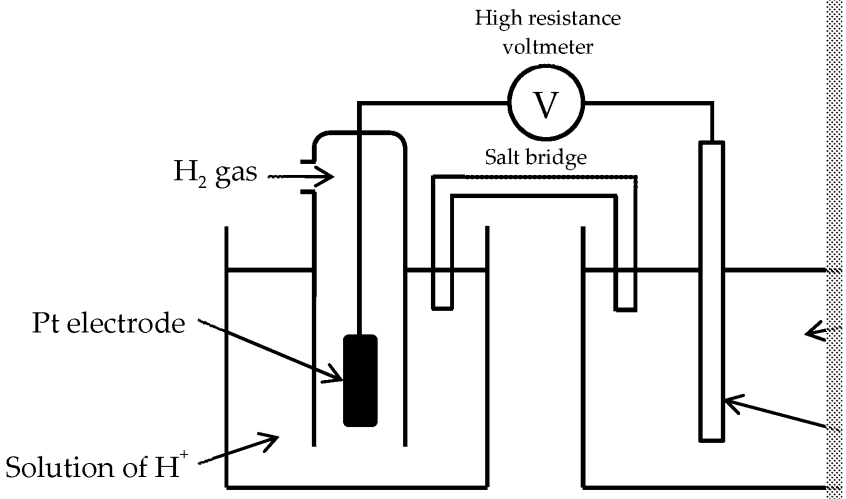
A Pb(s) and $Ag^+(aq)$

B Pb(s) and $Al^{3+}(aq)$

C Al(s) and $Pb^{2+}(aq)$

D Ag(s) and $Pb^{2+}(aq)$

5. Use the data given below to calculate the cell potential for the follow conditions are standard):



Half-cell					Standard electro
$2H^+(aq)$	+	$2e^-$	⇌	$H^2(g)$	
$Co^{2+}(aq)$	+	$2e^-$	⇌	Co(s)	
$Co^{3+}(aq)$	+	e^-	⇌	$Co^{2+}(aq)$	

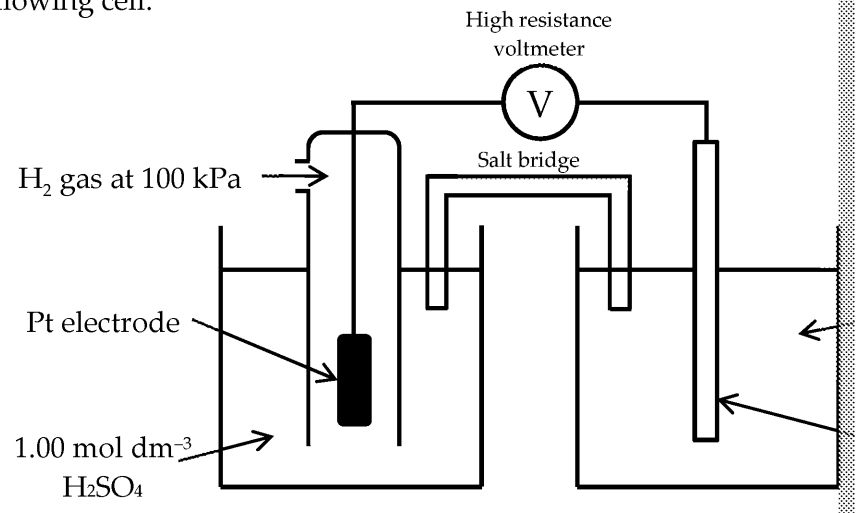
A -0.28 V

B 1.92 V

C 0.28 V

D -1.92 V

6. A student measures the electrode potential for the iron(III)/iron(II) following cell:



Her lab partner says that what has been measured is not a *standard* the conditions is non-standard?

A Hydrogen gas is at the wrong pressure.

B The temperature is wrong.

C The concentrations of the iron ions are wrong.

D The concentration of H^+ ions is wrong.

7. Which pair of half-equations below shows correct electrode reactio oxygen fuel cell, *assigned to the correct electrodes*?

Anode: $H_2 \rightarrow 2H^+ + 2e^-$

A Positive electrode: $H_2 + 4OH^- \rightarrow H_2O + 2e^-$
Negative electrode: $O_2 + H_2O + 4e^- \rightarrow 4OH^-$

B Positive electrode: $O_2 + H_2O + 4e^- \rightarrow 4OH^-$
Negative electrode: $H_2 + 4OH^- \rightarrow H_2O + 2e^-$

C Positive electrode: $H_2 \rightarrow 2H^+ + 2e^-$
Negative electrode: $H_2O + 2e^- \rightarrow 2OH^-$

D Positive electrode: $2H^+ + 2e^- \rightarrow H_2$
Negative electrode: $2OH^- \rightarrow H_2O + 2e^-$

8. Under standard conditions, the cell potential, E^θ, for each of the tw

$Co(s)|Co^{2+}(aq)||Cu^{2+}(aq)|Cu(s)$ $E^\theta = +0.$
$Ag(s)|Ag^+(aq)||Sn^{2+}(aq)|Sn(s)$ $E^\theta = -0.9$

Use this information to decide which of the following shows the co occur if these cells were set up.

A $Co(s) + Cu^{2+}(aq) \rightarrow Co^{2+}(aq) + Cu(s)$ and $Sn^{2+}(aq) + 2Ag(s) \rightarrow Sn($

B $Co^{2+}(aq) + Cu(s) \rightarrow Co(s) + Cu^{2+}(aq)$ and $Sn^{2+}(aq) + 2Ag(s) \rightarrow Sn($

C $Co^{2+}(aq) + Cu(s) \rightarrow Co(s) + Cu^{2+}(aq)$ and $Sn(s) + 2Ag^+(aq) \rightarrow Sn^{2+}$

D $Co(s) + Cu^{2+}(aq) \rightarrow Co^{2+}(aq) + Cu(s)$ and $Sn(s) + 2Ag^+(aq) \rightarrow Sn^{2+}$

9. One type of fuel cell uses the reaction of methanol with oxygen to produ
equation for the reaction in the fuel cell and the half-equation for the po

Overall: $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$
Positive electrode: $3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O$

Which of these is the correct half-equation for the reaction at the nega
such a way that it will combine with the positive electrode half-equati
equation as it is shown above?

A $2CH_3OH + 2H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$

B $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$

C $CO_2 + 6H^+ + 6e^- \rightarrow CH_3OH + H_2O$

D $2CO_2 + 12H^+ + 12e^- \rightarrow 2CH_3OH + 2H_2O$

10. Which pair of statements correctly describes *both* a benefit and a risk
fuel cell?

A The fuel cell produces harmful polluting gases.
The fuel cell uses a cheap gas as the fuel.

B The fuel cell produces no polluting gases.
The fuel cell uses an explosive gas as the fuel.

C The fuel cell produces toxic waste products.
The fuel cell uses a sustainable fuel.

D The fuel cell produces waste products that are easy to capture an
The fuel cell is less efficient than a combustion engine using the s

Topic 5: Transition Metals

1. Which of these shows the correct electronic configuration for a copp

   A $[Ar]3d^9 4s^2$

   B $[Ar]3d^{10} 4s^1$

   C $[Kr]3d^9 4s^2$

   D $[Kr]3d^{10} 4s^1$

2. Which of the following could correctly describe $[NiCl_4]^{2-}$? Give all of

   1: It is a tetrahedral complex ion.
   2: It has a coordination number of 4.
   3: It has cis-trans isomers.

   A 1 only

   B 2 only

   C 1 and 2

   D 1, 2 and 3

3. In the ion shown below, what is the most accurate term to describe th in bold)?

   $[Cu\mathbf{Cl}_4]^{2-}$

   A Ligand

   B Molecule

   C Atom

   D Complex

4. Why is zinc not considered to fit the definition of a transition elemen

   A It is not in the d block of the periodic table.

   B It is not a good catalyst.

   C It does not have enough oxidation states.

   D Zinc ions always have a full d-subshell.

5. When an orange solution of chromium(VI) ions reacts with zinc meta green and then to blue as the chromium(VI) ions are converted to chr chromium(II) ions.

   Which of these characteristics of transition elements does this demon

   1: Catalytic behaviour
   2: Coloured ions
   3: Variable oxidation states

   A 1 only

   B 2 only

   C 2 and 3 only

   D 1, 2 and 3

6. Which is the correct description for reaction shown below?

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(H_2O)_2(NH_3)_4]^{2-}(a$$

A Complete ligand substitution with a change of coordination nur
B Incomplete ligand substitution with a change of coordination nu
C Complete ligand substitution without a change of coordination
D Incomplete ligand substitution without a change of coordinatio

7. What is the name for the *specific* explanation of the increased stability c replacing monodentate ligands in complex ions?

A Ligand substitution
B Redox
C Autocatalysis
D The chelate effect

8. When concentrated hydrochloric acid is added to an aqueous solution following reaction happens:

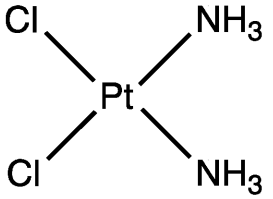
$$[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6$$

Which is the correct explanation for why four chloride ions replace s

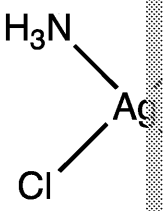
A Chloride ions have a negative charge, causing them to repel one four can be in a complex ion.
B Chloride ions are larger than water molecules, so fewer of them ca ion.
C Chloride ions are multidentate, and so four of them in a comple coordination number as six monodentate ligands.
D Chloride ions form stronger bonds to copper than water molecu needed to make a stable complex.

9. Which is the correct structure of cisplatin?

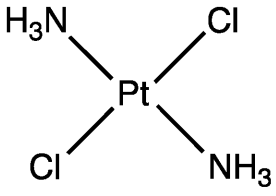
A



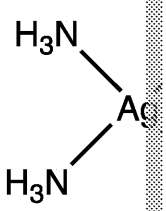
C



B



D



10. Which of the following is **least likely** to affect the difference in ener state and excited state of d-electrons in a transition metal complex io

A A change in the oxidation state of the transition metal
B A change in the coordination number of the complex ion
C A change from cis isomer to trans isomer
D A change of ligands in the complex ion

11. When the ion VO_2^+ is reacted with zinc and hydrochloric acid in an
solution turns blue then green then violet and finally returns to a g
explanation for these observations?

A Zinc reduces the vanadium(V) species to vanadium(IV) then
vanadium(II) and finally to vanadium(I).

B Zinc reduces the vanadium(V) species to vanadium(IV) then
vanadium(II), which oxidises in the air back to vanadium(III)

C Zinc reduces the vanadium(IV) species to vanadium(III) then
vanadium(I), which oxidises in the air back to vanadium(II).

D Zinc reduces the vanadium(VI) species to vanadium(V) then
vanadium(III) and finally to vanadium(II).

12. What chemical process is responsible for the toxicity of carbon mono

A The oxidation of CO to CO_2 by oxygen in the blood stream

B The dissociation of CO to form dangerous oxygen radicals in t

C The oxidation of iron(II) to iron(III) by CO

D The replacement of O_2 by CO as a ligand in haem

13. Which of the following correctly shows an iron species acting as a
reaction between solutions of KI and $Na_2S_2O_8$?

A $2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow Fe^{3+}(aq) + 2SO_4^{2-}(aq)$
$2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$

B $S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow Fe\ 2SO_4^{2-}(aq) + I_2(aq)$

C $2Fe^{3+}(aq) + S_2O_8^{2-}(aq) \rightarrow Fe^{2+}(aq) + 2SO_4^{2-}(aq)$
$2Fe^{2+}(aq) + 2I^-(aq) \rightarrow 2Fe^{3+}(aq) + I_2(aq)$

D $S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow FeCl_2\ 2SO_4^{2-}(aq) + I_2(aq)$

14. In what capacity does iron metal act in the Haber process?

A As a homogenous catalyst

B As a heterogeneous catalyst

C As an autocatalyst

D As a support medium for other catalysts

15. Which is the correct description of the observations that you would
iron(III) nitrate and ammonium iron(II) sulfate are added to sodiu

A The iron(III) compound would produce an orange/brown preci
effervescence. The iron(II) compound would produce a green p
effervescence.

B The iron(III) compound would produce a green precipitate and
effervescence. The iron(II) compound would produce an oran
no effervescence.

C The iron(III) compound would produce a green precipitate wit
iron(II) compound would produce an orange/brown precipitat
effervescence.

D The iron(III) compound would produce an orange/brown preci
effervescence. The iron(II) compound would produce a green p
would be effervescence.

Topic 6: Kinetics II

1. Use the initial rates data below to help you select the correct rate equ

$H_2SeO_3(aq) + 4I^-(aq) + 4H^+(aq) \rightarrow Se(s) + 2I_2(aq) +$

	$[H_2SeO_3]$ /mol dm^{-3}	$[I^-]$ /mol dm^{-3}	$[H^+]$ /mol dm^{-3}	I
1	0.0010	0.10	0.10	
2	0.0020	0.10	0.10	
3	0.0010	0.20	0.10	
4	0.0010	0.10	0.20	

A Rate = $k[H_2SeO_3][I^-][H^+]^2$

B Rate = $k[H_2SeO_3][I^-][H^+]$

C Rate = $k[H_2SeO_3][I^-]^2[H^+]^2$

D Rate = $k[H_2SeO_3][H^+]$

2. The rate equation for the reaction between two compounds, A and B
Which of the following factors would cause the value of the rate cons

1: Increasing temperature
2: Increasing the concentration of A
3: Increasing the concentration of B

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

3. Which of the following rate equations is for a reaction that is second

A Rate = $k[A]^2[B]^2$

B Rate = $k[A][B]^2$

C Rate = $k[A][B]$

D Rate = $k[A]^2[B]$

4. The rate of the reaction between H_2O_2 and I_2 is given by the equation
initial rates data below to choose the correct value for the rate consta

$[H_2O_2]$ / mol dm^{-3}	$[I_2]$ / mol dm^{-3}	Rate /
0.260	0.320	

A 0.0208 dm^3 mol^{-1} min^{-1}

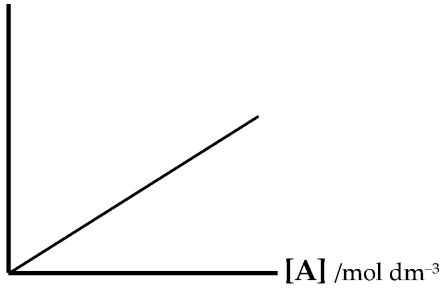
B 3.00 dm^3 mol^{-1} min^{-1}

C 0.333 dm^3 mol^{-1} min^{-1}

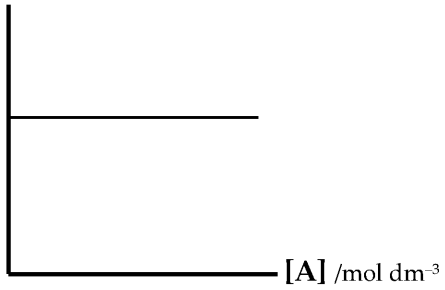
D 48.1 dm^3 mol^{-1} min^{-1}

5. If a reaction of a single reactant, A, is first order, which graph represe
reaction against concentration of A?

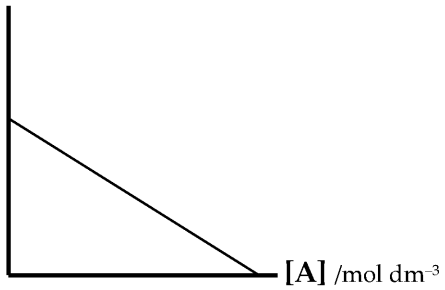
A



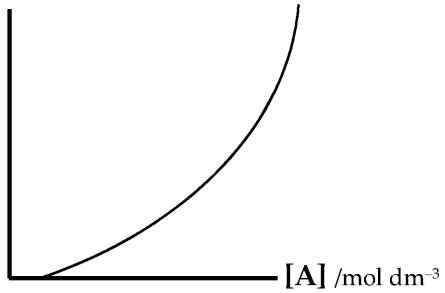
B



C



D



6. In the reaction of sodium hydrogen carbonate solution with hydro
produced. The data below shows how long a series of reactions to
carbon dioxide.

The reaction is first order with respect to both hydrogencarbonate
Use this information to predict the missing value for the time taken

Experiment	$[HCO_3^-]$ /mol dm^{-3}	$[H^+]$ /mol dm^{-3}	
1	0.005	0.125	
2	0.010	0.125	
3	0.005	0.250	

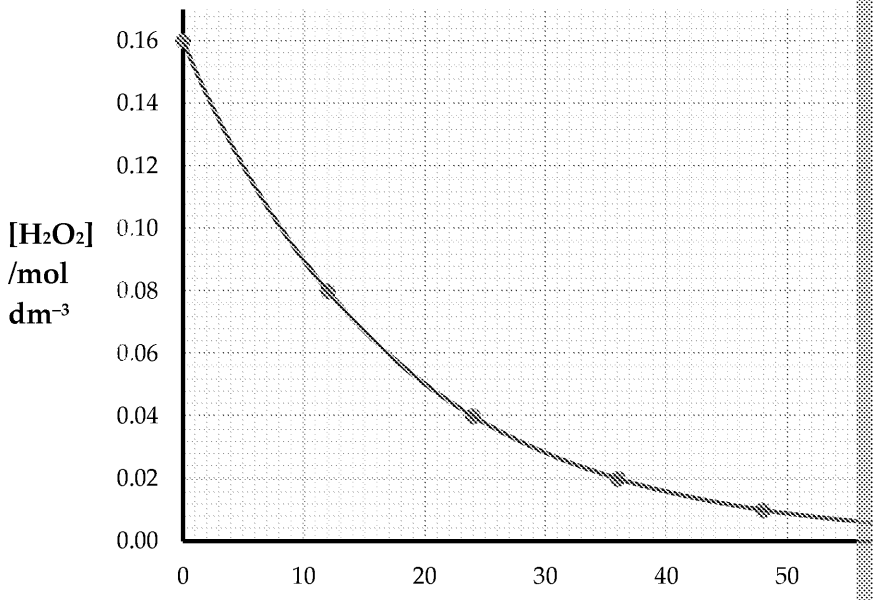
A 312

B 39

C 156

D 78

7. A concentration–time graph for the first-order decomposition of hy
below. Use this graph to determine the rate of decomposition of hy
after the start of the reaction.



A 797 mol dm^{-3} s^{-1}

B 1.25×10^{-3} mol dm^{-3} s^{-1}

C 0.012 mol dm^{-3} s^{-1}

D 83.3

8. Which of the following techniques is an *initial rate method* (sometim
could be used to measure the rate of the reaction between peroxodi
The equation for this reaction is:

$$S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$$

A Perform the reaction in a tube in a colorimeter. At regular inte
values from the colorimeter and plot an absorbance–time grapl

B Use a conductivity meter to monitor the electrical conductivity
Record conductivity values at regular intervals and plot a conc

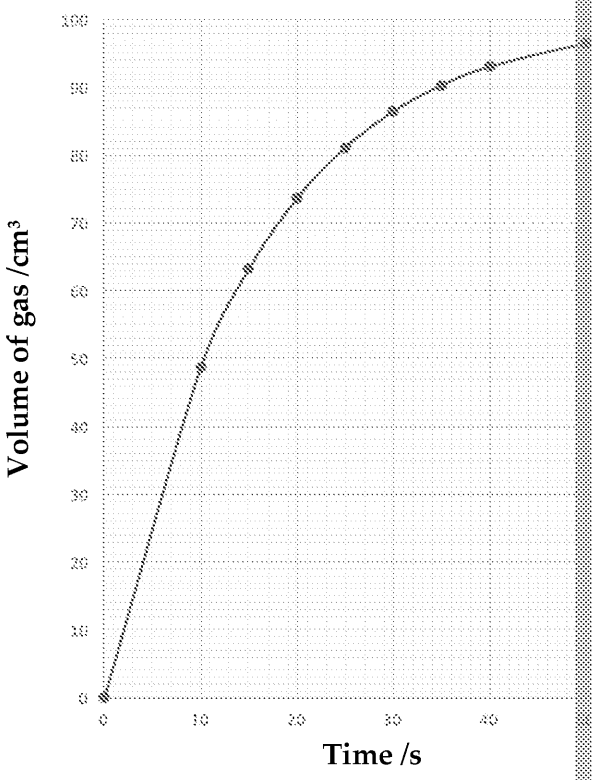
C Add a small quantity of starch to the reaction mixture to form a
complex with the iodine that is formed. Time how long it take

D Add a small quantity of reducing agent to the reaction mixture
initially formed. Add starch to indicate the presence of iodine.
agent is exhausted, the colour of iodine will be seen and the tim

9. Magnesium metal reacts with hydrochloric acid according to this eq

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The volume of gas produced in this reaction was recorded at regular graph below.



What is the initial rate of the reaction?

A 0.2 $cm^3\ s^{-1}$

B 49 $cm^3\ s^{-1}$

C 1.6 $cm^3\ s^{-1}$

D 4.9 $cm^3\ s^{-1}$

10. Sodium thiosulfate reacts with hydrochloric acid according to the fo

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + SO_2(g) + S$$

Which of the following techniques could be used to continuously mo

A Measure the rate at which the $Na_2S_2O_3$ is used up by measuring vanishes.

B Measure the rate at which the HCl is used up by measuring hov solution increases.

C Measure the rate at which the NaCl is produced by measuring h colour appears.

D Measure the rate at which the SO_2 is produced by measuring ho solution decreases.

11. The decomposition of hydrogen peroxide, $2H_2O_2 \rightarrow 2H_2O + O_2$, is ca
The rate equation for this reaction is found to be: Rate = $k[H_2O_2][I^-]$.

Which of the following is a possible mechanism for this reaction tha
rate equation?

A $2H_2O_2 + I^- \longrightarrow 2H_2O + IO_2^-$ **SLOW step**
$IO_2^- \longrightarrow O_2 + I^-$ **FAST step**

B $2H_2O_2 + I^- \longrightarrow 2H_2O + IO_2^-$ **FAST step**
$IO_2^- \longrightarrow O_2 + I^-$ **SLOW step**

C $H_2O_2 + I^- \longrightarrow H_2O + IO^-$ **SLOW step**
$H_2O_2 + IO^- \longrightarrow H_2O + O_2 + I^-$ **FAST step**

D $H_2O_2 + I^- \longrightarrow H_2O + IO^-$ **FAST step**
$H_2O_2 + IO^- \longrightarrow H_2O + O_2 + I^-$ **SLOW step**

12. The Arrhenius equation, $k = Ae^{-Ea/RT}$, shows how the rate of a reactic
constant, k) is affected by temperature, T. Which of the following st
explains this relationship?

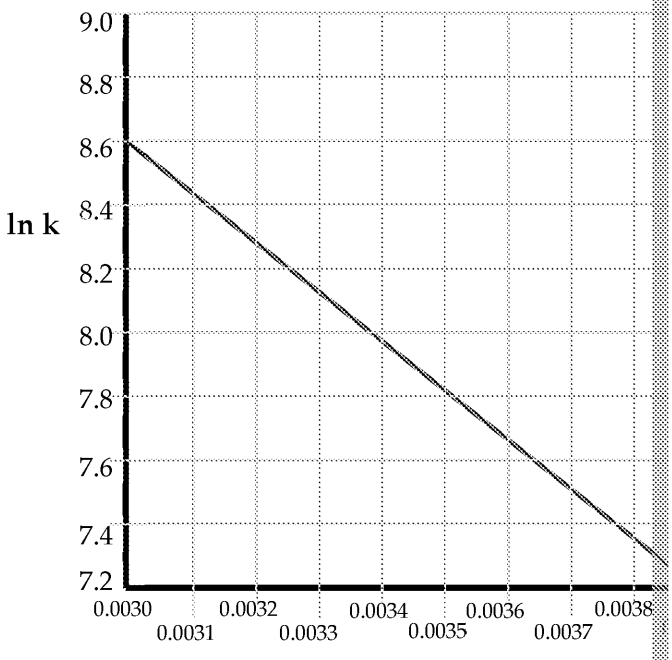
A As T increases, a greater proportion of particles have energy gre
increases linearly.

B As T increases, particles move with higher velocity, and k decre

C As T increases, particles collide more frequently and a greater p
have energy greater or equal to Ea, and k increases exponentiall

D As T increases, particles move with higher velocity, and k decre

13. One form of the Arrhenius equation is: $\ln k = -E_a/RT + \ln A$. Use the
correct values for the activation energy, E_a. Take the value of R to be



A $E_a = 12.9$ kJ mol^{-1}

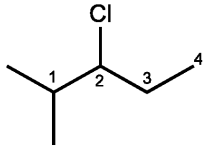
B $E_a = 1.56$ kJ mol^{-1}

C $E_a = 7.35$ kJ mol^{-1}

D $E_a = 256$ kJ mol^{-1}

Topic 7: Organic Chemistry II

1. Which of the carbons labelled is chiral in the following molecule?



A 1

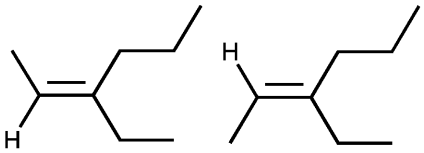
B 2

C 3

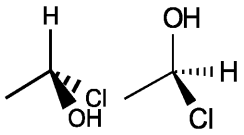
D 4

2. Which of the following pairs of molecules are optical isomers?

A

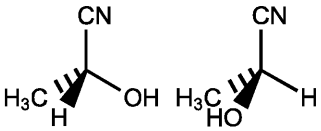


B



C

D



3. What is the best definition of the term *enantiomers*?

A A pair of isomers that are mirror images of each other

B A pair of isomers that have the same structural formula but differ

C A pair of stereoisomers that do not have free rotation

D A pair of structural isomers that have four different groups attach

4. Which of the following compounds can be reacted with sodium boro produce *propan-1-ol*?

1: Propanone
2: Propanal
3: Propanoic acid

A 1 and 2

B 1 and 3

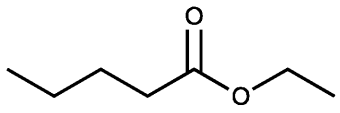
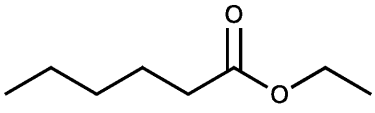
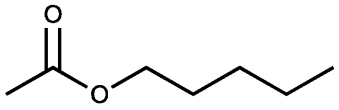
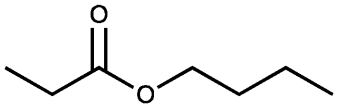
C 2 only

D 1, 2 and 3

5. By which type of mechanism does a cyanide ion react with a keton
   A Nucleophilic addition
   B Electrophilic addition
   C Nucleophilic substitution
   D Electrophilic substitution

6. Which is the correct product of the reaction that occurs when KCN
   by dilute acid?
   A 2-hydroxybutanenitrile
   B 2-hydroxypropanenitrile
   C butanenitrile
   D propanenitrile

7. Which of the following compounds would react with KCN followe
   mixture of enantiomers?
   1: Propanal
   2: Butanone
   3: Propanone
   A 1 only
   B 1 and 2 only
   C 2 and 3 only
   D 1, 2 and 3

8. Which of the following esters is ethyl pentanoate?
   A 
   B 
   C 
   D 

9. What is the correct name of the product of the reaction between pr
   A Propyl ethanoate
   B Propanoyl ethanoate
   C Ethyl propanoate
   D Ethanoyl propanoate

10. Which of the following compounds could be prepared using ethan

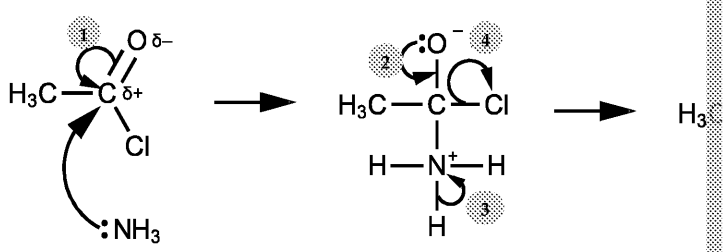
A Ethyl propanoate

B N-methylethanamide

C Ethyl benzoate

D N-ethylmethanamide

11. Which of the following arrows in the mechanism is **incorrect**?



A 1

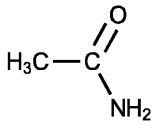
B 2

C 3

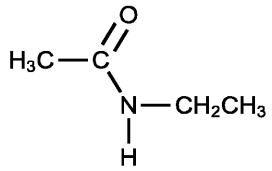
D 4

12. Which of the following is a correct product of the nucleophilic addit between an ethanoyl chloride and excess ethylamine?

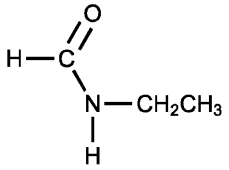
A



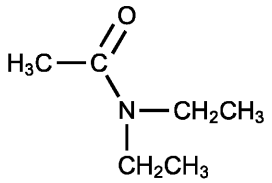
B



C



D



13. Which of the following pairs of substances could react to form biod

A Methanoic acid and vegetable oil

B Methanoic acid and crude oil

C Methanol and vegetable oil

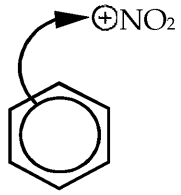
D Methanol and crude oil

Topic 8: Organic Chemistry III

1. Which of the following pieces of evidence helped to convince the scie benzene molecules contain a delocalised π-system?
   A The C–C bonds in benzene were found to be exactly the same le
   B Three of the C–C bonds in benzene were found to be longer tha suggesting the structure has alternating double and single bond
   C The C–C bonds in benzene were found to be shorter than typica than typical double bonds.
   D Attempts to measure the C–C bond lengths in benzene failed be carbon atoms are not fixed.

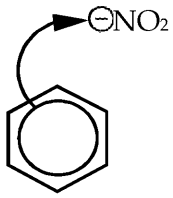
2. Which of the following equations regenerates the catalyst in the nitratic
   A $HSO_4^- + H^+ \rightarrow H_2SO_4$
   B $NO_3^- + H^+ \rightarrow HNO_3$
   C $SO_3^- + H_2O \rightarrow H_2SO_4$
   D $NO_2^+ + H_2O \rightarrow HNO_3$

3. Which of these is a correct step in the mechanism of the reaction of b presence of sulfuric acid?

A 

☐

C 
☐

B 

☐

D 
☐

4. Aromatic compounds can be acylated using a Friedel–Crafts catalyst equations correctly shows how the catalyst helps to form the electrop ring in an acylation reaction?
   A $RCOBr + HNO_3 \rightarrow RCO^+ + NO_3^- + HBr$
   B $RCOBr + FeBr_3 \rightarrow RCO^+ + FeBr_4^-$
   C $RCH_2Br + HNO_3 \rightarrow RCH_2^+ + NO_3^- + HBr$
   D $RCH_2Br + FeBr_3 \rightarrow RCH_2^+ + FeBr_4^-$

5. Which of the following materials can be made by nitrating the aroma methylbenzene?
   A A dye
   B A painkiller
   C A plastic
   D An explosive

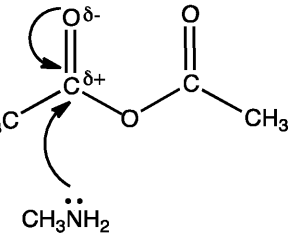
6. Which of the following statements about the base strength of ammo phenylamine is/are correct?

    1: Ammonia is a stronger base than methylamine.
    2: Ammonia is a stronger base than phenylamine.
    3: Methylamine is a stronger base than phenylamine.

    A 1 only
    B 2 only
    C 1 and 2 only
    D 2 and 3 only

7. Which of the following is a correct step in the mechanism of the rea ethanoic anhydride?

A



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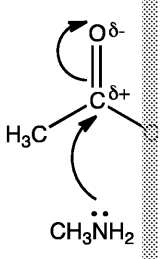
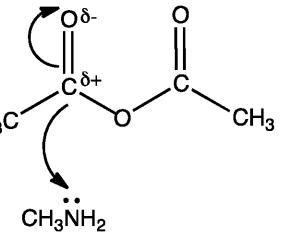
C



B



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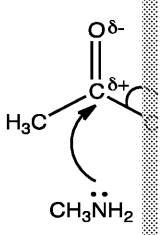
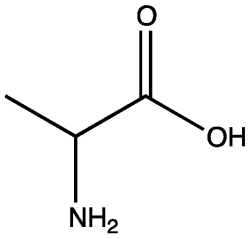
D



8. Which of the following structures is the correct one for the amino a (i.e. in alkaline conditions)?

A



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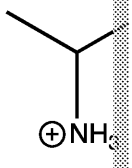
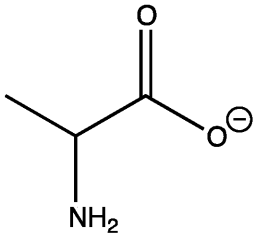
C



B



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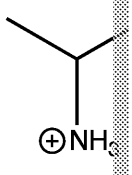
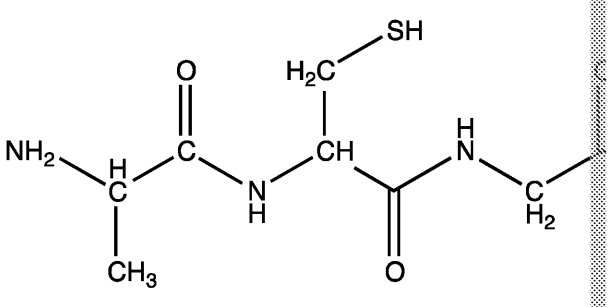
D



9. Which of the following is the correct general formula for an α-amin

    A RCH_2COOH
    B $R(NH_2)CH_2$
    C $NH_2CH_2RCHCOOH$
    D $RCH(NH_2)COOH$

10. Which amino acids will be produced if this tripeptide is hydrolysed



A NH_2CH_2COOH, $NH_2CH(SH)COOH$, $NH_2CH(CH_3)COOH$

B $NH_2CH(CH_3)COOH$ and $NH_2CH(CH_2SH)COOH$

C NH_2CH_2COOH, $NH_2CH(CH_2SH)COOH$, $NH_2CH(CH_3)COC$

D NH_2CH_2COOH and $NH_2CH(SH)COOH$

11. Which of these syntheses of propanoic acid involves the least-hazar waste products?

A $CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$

B $CH_3CH_2Cl + HCN \rightarrow CH_3CH_2CN + HCl$;
$CH_3CH_2CN + 2H_2O + HCl \rightarrow CH_3CH_2COOH + NH_4Cl$

C $3CH_3CH_2CH_2OH + Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3CH_2COOH + 4Cr^3$

D $(CH_3CH_2CO)_2O + H_2O \rightarrow 2CH_3CH_2COOH$

12. Which of the following schemes is a possible way of making propylan

A
1. $CH_3CH_2Br \xrightarrow{NaCN} CH_3CH_2CN + NaBr$
2. $CH_3CH_2CN \xrightarrow{LiAlH_4} CH_3CH_2CH_2NH_2$

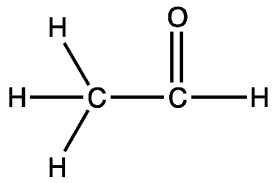
B
1. $CH_3CH_2Br \xrightarrow{NH_3} CH_3CH_2NH_3^+Br^-$
2. $CH_3CH_2NH_3^+Br^- \xrightarrow{OH^-} CH_3CH_2NH_2 + H_2O + Br^-$

C
1. $CH_3CH_2Br \xrightarrow{H_2O} CH_3CH_2OH + HBr$
2. $CH_3CH_2OH \xrightarrow{CH_3NH_2} CH_3CH_2CH_2NH_2 + H_2O$

D
1. $CH_3CH_2Br \xrightarrow{H^+} CH_2{=}CH_2 + HBr$
2. $CH_2{=}CH_2 \xrightarrow{NH_3} CH_3CH_2NH_2$

Topic 9: Modern Analytical Techniqu

1. What would be the integration ratio of the two signals in the ^1H NMR shown below?

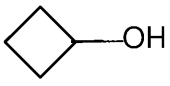


A 1:3
B 2:4
C 1:2
D 1:1

2. How many signals would you expect to see in the carbon-13 NMR spect
A 1
B 2
C 3
D 4

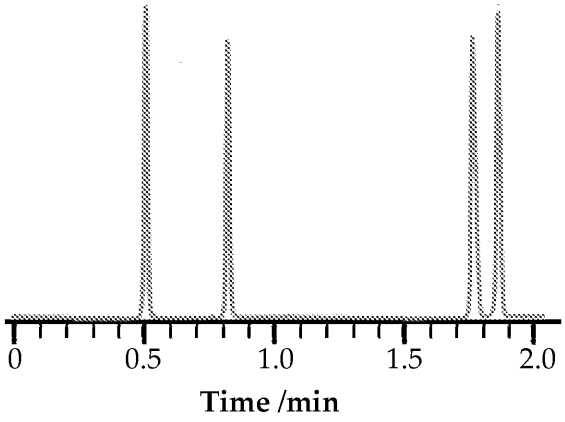
3. Which isomer with the formula C_4H_8O would give the carbon-13 NMR
The chemical shift values of the peaks are not needed to answer this q

A Butanone, $CH_3CH_2COCH_3$

B Cyclobutanol, 

C But-1-ene-2-ol, $CH_2=C(OH)CH_2CH_3$
D Butanal, $CH_3CH_2CH_2CHO$

4. Use the following gas chromatogram plus the table of data to identi
the mixture.



Compound
methanol
ethanol
propan-1-ol
propan-2-ol
methanal
ethanal
propanal
propanone

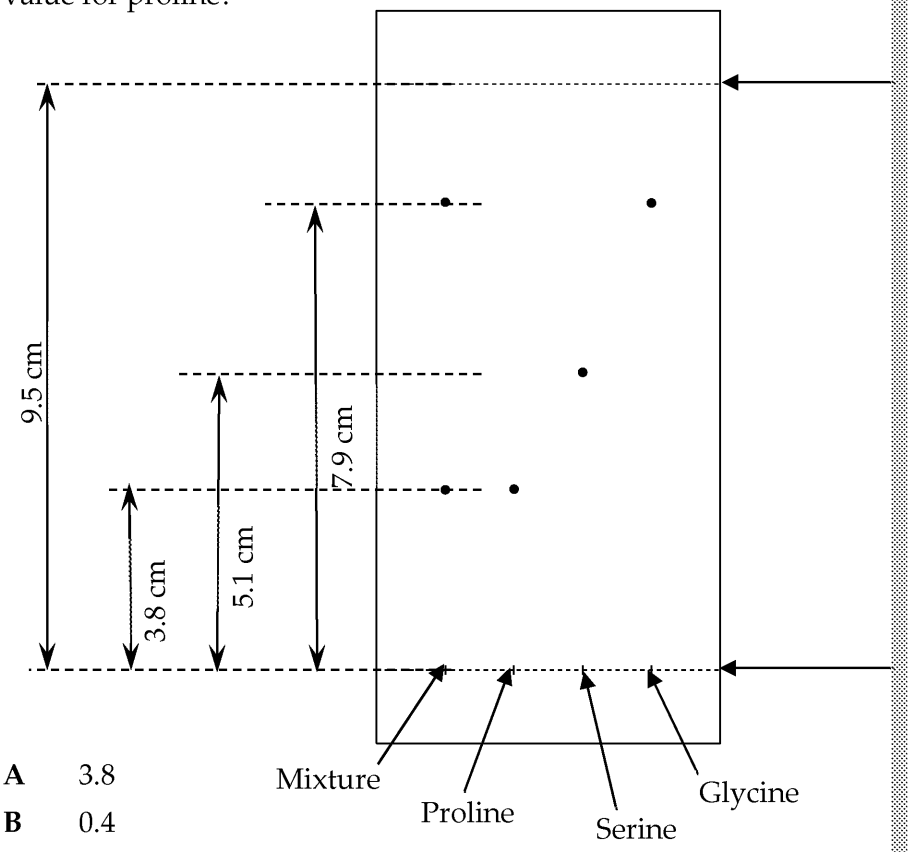
A Ethanal, ethanol, propanone, propan-2-ol
B Methanol, ethanol, propanone, propan-2-ol
C Methanal, ethanol, propanal, propan-2-ol
D Ethanal, ethanol, propanal, propan-1-ol

5. A mixture of methanal and methanol is passed through a gas chron
emerges first, followed by the methanol. Which of these statements
for why this is?

1: Methanol has a higher M_r value than methanal.
2: Methanol has a higher affinity for the stationary phase tha
3: Methanal has a higher affinity for the moving phase than

A 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

6. The diagram below shows a TLC chromatogram run on a number of value for proline?



A 3.8
B 0.4
C 2.5
D 0.48

7. Mass spectroscopy resolves ions into their characteristic mass peaks a mass-to-charge ratio. Which of the following elements is responsible

A Ion source
B Analyser tube
C Analyser
D Detector system

8. Which of the following elements is the basis of the separation of ions

A Mass
B Charge
C Molecular weight
D Mass-to-charge ratio

Section B Quick Answers

Topic 1: Equilibrium II

1. A
2. D
3. B
4. D
5. C
6. C
7. D

Topic 2: Acid-Base Equilibria

1. B
2. C
3. A
4. C
5. D
6. A
7. C
8. A
9. C
10. A
11. D
12. D
13. B
14. A

Topic 3: Energetics II

1. C
2. B
3. D
4. B
5. A
6. A
7. D
8. C
9. B
10. C

Topic 4: Redox II

1. C
2. A
3. D
4. C
5. A
6. D
7. B
8. D
9. A
10. B

Topic 5: Transition Metals

1. B
2. C
3. A
4. D
5. C
6. D
7. D
8. B
9. A
10. C
11. B
12. D
13. A
14. B
15. A

Topic 6: Kinetics

1. A
2. A
3. C
4. B
5. A
6. D
7. B

Topic 7: Organic

1. B
2. D
3. A
4. C
5. A
6. A
7. B

Topic 8: Organic

1. C
2. B
3. A
4. B
5. D
6. D

Topic 9: Modern

1. A
2. B
3. B
4. A