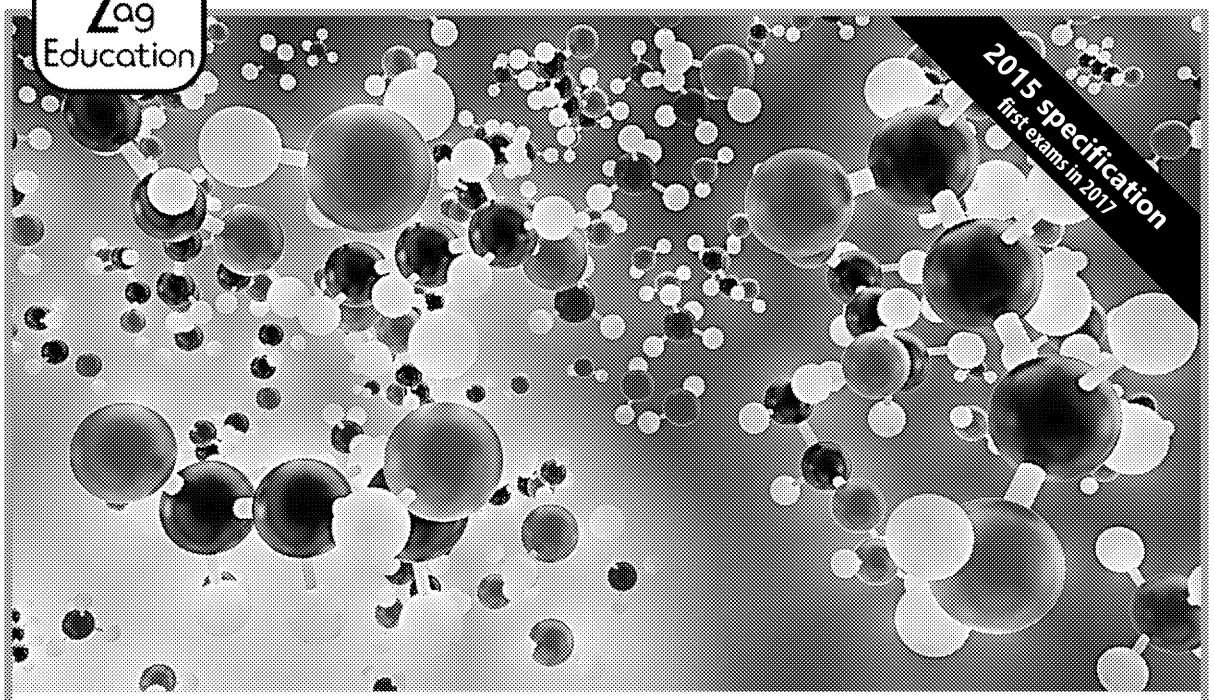
Zig Zag Education

Chemistry **A Level | OCR A | H432**



Multiple-choice Practice Questions

for A Level Year 2 OCR Chemistry A

zigzageducation.co.uk **POD 7595**

Contents

Teacher's Introduction

For the A Level Year 2 Chemistry course, the OCR A exam board includes strong emphasis on multiple-choice questioning which is assessed in Section A of Papers 1 and 2. The assessment marks awarded for the multiple-choice section are 15 marks out of an available 100 marks for the whole of components 01 and 02.

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 modules 5 and 6 of the A Level course.

The resource is split into two sections:

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

Section A: Multiple-choice Question Bank 1
This section includes over 100 multiple-choice questions that span each topic making up the Year 2 A Level content. The questions mimic the exam style of the OCR 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 end of the resource, 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 themselves for next time.

Section B: Multiple-choice Question Bank 2
This section includes another set of multiple-choice questions that similarly span each topic that makes 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 resource. The mark scheme does not include worked solutions.

May 2017

Student's Introduction

Aim:
This pack is designed to help you practise your multiple-choice questions and, with the worked solutions, allow you to build effective strategies for completing these questions. Multiple-choice questions now make up 15 of the 100 marks available on each of the A Level Year 2 Chemistry Papers 1 and 2 and, therefore, this pack aims to provide you with the tools to confidently tackle your upcoming exam.

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

- **Module 5:** Physical chemistry and transition elements
- **Module 6**: Organic chemistry and analysis

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

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-marking your solutions against the worked answers and commentary given in the answers section. You should work through the solutions to Section A, taking note of your mistakes and ensuring that you understand where you went wrong, before continuing with Section B.
- After completing Section B you can proceed by self-marking your solutions against the answers section. Additionally, you can compare your answers to those obtained in Section A to assess whether you have improved your skills and identify areas that still need further work.

Topic 1: Orders, Rate Equations and Rate C

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

$$2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O$$

	$[I^-]$ / mol dm^{-3}	$[H_2O_2]$ / 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. In the rate equation, Rate = $k[A]^2[B]$, which of the following could be t constant, k?

A dm^9 mol^{-3} s^{-1}

B mol^2 dm^{-6} s^{-1}

C dm^6 mol^{-2} s^{-1}

D mol^3 dm^{-9} s^{-1}

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

A Rate = $k[X]^2[Y][Z]$

B Rate = $k[X][Y]^3$

C Rate = $k[X][Y]$

D Rate = $k[X]^2[Y]$

4. 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}	$[H_2]$ / 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}

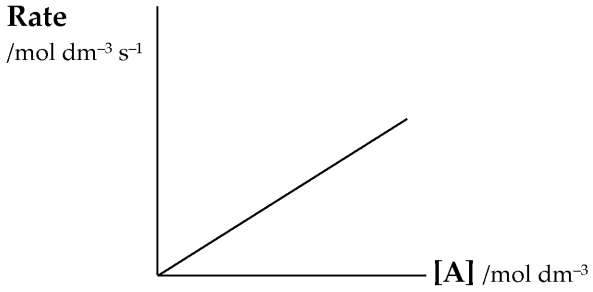
C 1.54×10^5 dm^6 mol^{-2} min^{-1}

D 7.18×10^{-4} dm^6 mol^{-2} min^{-1}

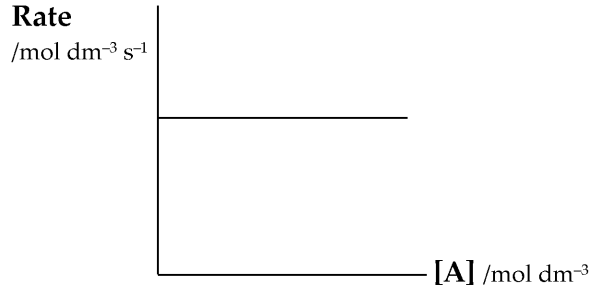
Topic 2: Rate Graphs and Orders

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

A



B



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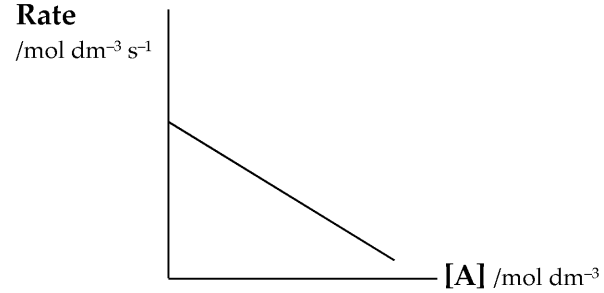
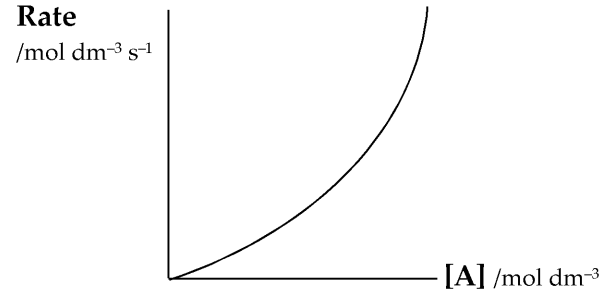
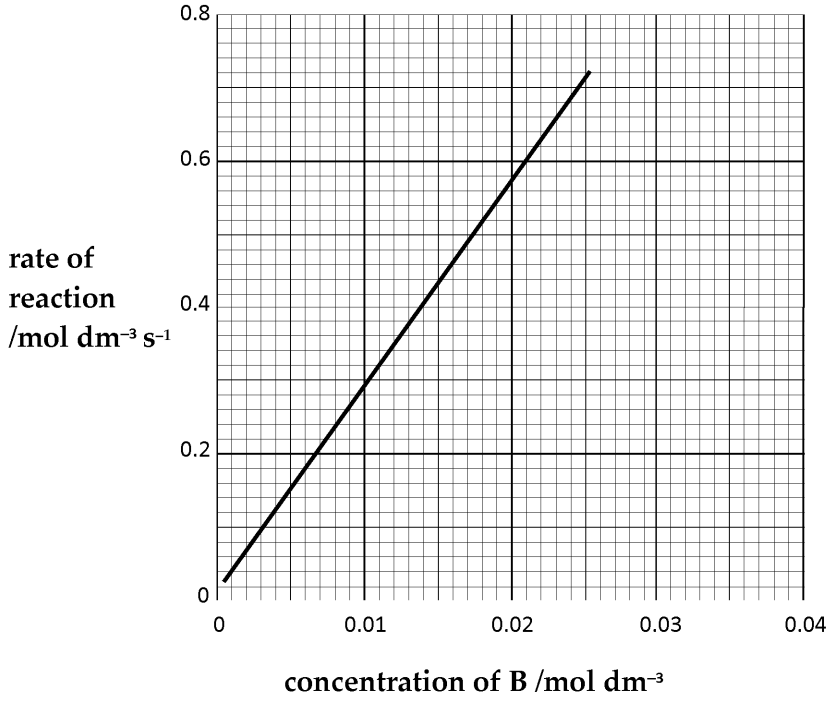


D



2. A reaction is first order with respect to [B]. Use the following graph o against [B] to determine the value of the rate constant, k, for the reac



A $k = 28\ s^{-1}$

B $k = 0.036\ s^{-1}$

C $k = 2.8\ s^{-1}$

D $k = 0\ s^{-1}$

3. The rate of decomposition of dinitrogen pentoxide, N_2O_5, to form NO rate equation: rate = $k[N_2O_5]$. At a certain temperature, the time take fall to half of its initial value is measured as 265 s. What is the correc k, calculated from this time?

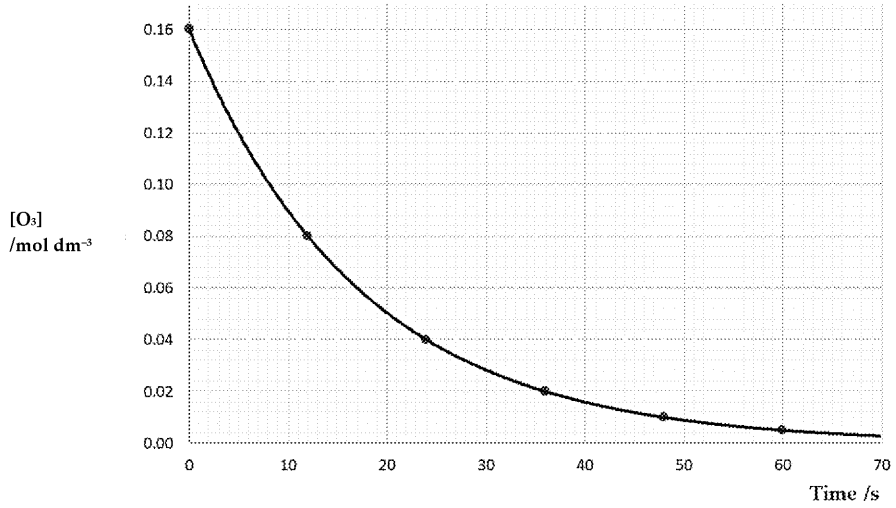
A $3.77 \times 10^{-3}\ s^{-1}$

B $7.55 \times 10^{-3}\ s^{-1}$

C $-4.89\ s^{-1}$

D $2.62 \times 10^{-3}\ s^{-1}$

4. The decomposition of ozone is a first order reaction. Use the followi
half-life, $t_{½}$, of ozone.



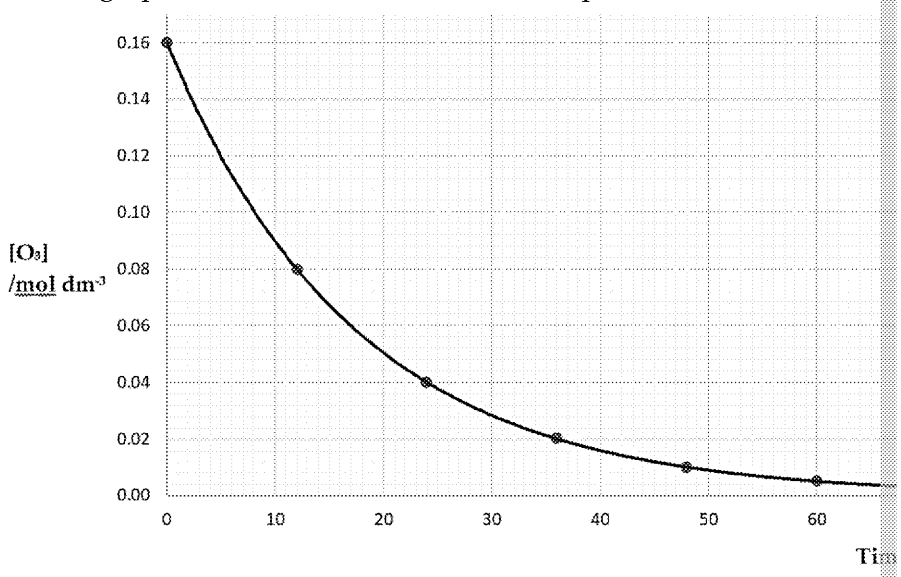
A $t_{½} = 70$ s

B $t_{½} = 12$ s

C $t_{½} = 36$ s

D $t_{½} = 35$ s

5. A concentration–time graph of the first order decomposition reaction
Use the graph to determine the rate of decomposition of ozone 20 s a



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}

6. Benzenediazonium chloride reacts with water according to the follow

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

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

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 describes which techniques coul
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 fo

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

7. The oxidation of iodide ions by hydrogen peroxide in the presence o
thiosulfate and a starch indicator is an example of a *clock* reaction. W
two correct reasons for why this is a convenient practical way of dete

A There is an easily detectable change during the reaction; it is pos
estimate the initial rate of reaction before a significant amount o
used up.

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

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

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

8. In order to investigate the rate of

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

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 mechan

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

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

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

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

Topic 3: Effect of Temperature on Rate C

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

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.

2. The Arrhenius equation can be converted into the following: ln k = -E following correctly describes a graphical method of determining the reaction?

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

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

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

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

Topic 4: Equilibrium

1. The following statements are definitions of terms related to gas-phas
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 r
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 gase
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

$$2HI \rightleftharpoons H_2 + I_2$$

Under certain conditions the value of the equilibrium constant, K_c, is 0
an equilibrium is established under these conditions (in which it is kn
concentrations of both H_2 and I_2 is 1.95×10^{-3} mol dm^{-3}), what is the eq
HI?

A 0.0133 mol dm^{-3}

B 0.301 mol dm^{-3}

C 1.77×10^{-4} mol dm^{-3}

D 2.86×10^{-4} mol dm^{-3}

3. The following are common laboratory techniques:

1: Titrating samples from the reaction
2: Colorimetry
3: Use of a pH meter

Which of these techniques could be used to determine the equilibriu
equilibrium in solution?

A Only 1

B Only 1 and 2

C Only 1 and 3

D 1, 2 and 3

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. Which is the correct expression for K_c for the following reaction?

$$Ag_2SO_4(s) \rightleftharpoons 2Ag^+(aq) + SO_4^{2-}(aq)$$

A $K_c = \dfrac{[SO_4^{2-}][Ag^+]^2}{[Ag_2SO_4]}$

B $K_c = [SO_4^{2-}][Ag^+]^2$

C $K_c = \dfrac{[Ag_2SO_4]}{[SO_4^{2-}][Ag^+]^2}$

D $K_c = [SO_4^{2-}][Ag^+]$

6. Which of the following shows the correct units for K_c for the followin

$$Sn^{2+}(aq) + 2Fe^{3+}(aq) \rightleftharpoons Sn^{4+}(aq) + 2Fe^{2+}(aq)$$

A mol dm^{-3}

B mol^3 dm^{-9}

C dm^9 mol^{-3}

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, pressure and the presence of a catalyst affect the follow

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

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 5: Brønsted–Lowry Acids and B

1. Which of the following statements about acids is correct?

1: Brønsted–Lowry acids are proton acceptors.
2: The Brønsted–Lowry definition of acids and bases is just one am
3: All weak acids have strong conjugate bases.

A Only 1

B Only 1 and 2

C Only 2 and 3

D None of the statements is correct.

2. Which of the following is a *tribasic* acid?

A H_3PO_4

B CH_3COONa

C HNO_3

D NH_3

3. Hydrochloric acid reacts with calcium carbonate according to the fol

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + C$$

Which is the correct *ionic* equation for this reaction?

A $2H^+(aq) + CO_3^{2-}(s) \rightarrow H_2O(l) + CO_2(g)$

B $2H^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

C $2H^+(aq) + 2Cl^-(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq) + H_2O(l) + C$

D $2H^+(aq) + 2Cl^-(aq) + Ca^{2+}(s) + CO_3^{2-}(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq) + H_2C$

4. Which of the following is the correct mathematical expression for the K_a, for a solution of a weak *monobasic* acid with general formula HA?

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

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

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

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

5. Which of the following statements are correct?

1: The value of K_a indicates the extent of dissociation of an acid – la proportion of the acid molecules have formed ions.
2: The value of pK_a indicates the extent of dissociation of an acid – l proportion of the acid molecules have formed ions.
3: The value of K_a can never be negative.

A Only 1

B Only 1 and 2

C Only 2 and 3

D 1, 2 and 3

6. What is the pH of a solution of a *dibasic*, *strong* acid with a concentra

A 1

B 0.7

C -1

D -0.7

7. If a solution of a strong *monobasic* acid has a pH of 1.3, what is the co solution?

A 0.050 mol dm^{-3}

B 20 mol dm^{-3}

C 0.11 mol dm^{-3}

D 13 mol dm^{-3}

8. What is the pH of a solution of sodium hydroxide with a concentrati

A 2.6

B 16.6

C 12

D 11.4

9. Taking the value of K_a for ethanoic acid as 1.76×10^{-5} mol dm^{-3}, whic correct pH for a solution of ethanoic acid with a concentration of 0.1

A 2.38

B 2.88

C 5.75

D 4.75

10. Use the data below to decide which of the following has the acids in from weakest to strongest acid.

Acid	pH of 1.0 mol dm^{-3} solution	K_a at 25 °C
ethanoic acid		1.76×10^{-5}
methanoic acid	1.88	
phenol		

A ethanoic acid, methanoic acid, phenol

B ethanoic acid, phenol, methanoic acid

C phenol, methanoic acid, ethanoic acid

D phenol, ethanoic acid, methanoic acid

11. Ethanoic acid is a weak acid with the formula CH_3COOH. Which o correct formula and description for the conjugate base of ethanoic a

A CH_3COO^-, which is a weak base

B CH_3COO^-, which is a strong base

C $CH_3COOH_2^+$, which is a weak base

D $CH_3COOH_2^+$, which is a strong base

Topic 6: Buffers and Indicators

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

1: Methanoic acid and sodium hydroxide
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

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

A 3.89

B 4.49

C 4.19

D 5.19

3. What is the correct definition of a *buffer solution*?

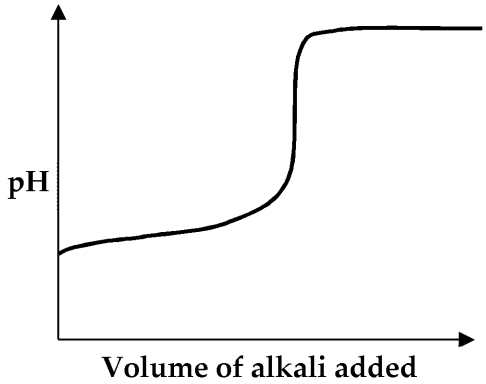
A A solution that maintains a constant pH in all chemical environm

B A solution whose pH does not change over long periods of time

C A solution that minimises the change in pH when small amounts added

D A solution whose pH can be calculated very accurately

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



A Ethanoic acid titrated against ammonia

B Ethanoic acid titrated against sodium hydroxide

C Sulfuric acid titrated against ammonia

D Sulfuric acid titrated against sodium hydroxide

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

Indicator	pH range ove
Indicator 1	
Indicator 2	
Indicator 3	
Indicator 4	

A Indicator 1

B Indicator 2

C Indicator 3

D Indicator 4

Topic 7: Lattice Energies

1. Which of the following is the correct definition for the term *molar lati*

A The energy change accompanying the formation of an ionic com from 1 mole of ions

B The energy change accompanying the formation of 1 mole of an gas phase from its ions

C The energy change accompanying the formation of 1 mole of an free ions in the gas phase

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

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

$\Delta_{LE}H\ (CaBr_2) = -2176\ kJ\ mol^{-1}$; $\Delta_{Hyd}H\ (Ca^{2+}) = -1650\ kJ\ mol^{-1}$; Δ_{Hy}

A 148 kJ mol^{-1}

B -4500 kJ mol^{-1}

C 189 kJ mol^{-1}

D -148 kJ mol^{-1}

3. Based on the data below, which of the compounds will have the mos (i.e. the largest negative value)?

Compound	Ions present	Radius of cation /pm
RbI	Rb^+ and I^-	149
MgO	Mg^{2+} and O^{2-}	72
CaO	Ca^{2+} and O^{2-}	100
$MgCl_2$	Mg^{2+} and Cl^-	72

A RbI

B MgO

C CaO

D $MgCl_2$

4. 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 $Na(g) \rightarrow Na^+(g) + e^-$

Topic 8: Entropy and Free Energy

1. Which of the following shows the set of compounds in the correct or
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 $CO_2(aq)$, $CO_2(s)$, $CO_2(g)$

2. 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}

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

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

B For an endothermic reaction with ΔS = -ve, the reaction is more l
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 b
temperature.

4. Calculations show that for a particular chemical reaction, the standar
the laboratory it is found that the chemical reaction appears not to be
temperature. Which of the following is the most likely reason for this

A The reaction is not feasible. Only reactions with positive values f

B ΔG tells us nothing about the kinetics of the reaction – it may be
to observe.

C The conditions in the laboratory may be non-standard and ΔG is
standard conditions.

D The calculation must contain an error. If ΔG is negative then the

Topic 9: Redox and Electrode Potent

1. Use the two half equations below to select the correctly balanced ove of manganate(VII) ions with hydrogen peroxide.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$$

A $MnO_4^- + O_2 + 10H^+ + 7e^- \rightarrow Mn^{2+} + 4H_2O + H_2O_2$

B $MnO_4^- + 6H^+ + H_2O_2 + 3e^- \rightarrow Mn^{2+} + 4H_2O + O_2$

C $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

D $2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 3H_2O + 5O_2$

2. The concentration of a solution of sodium thiosulfate can be determi iodine solution of known concentration. Starch has to be added to th the titration. Why is this?

A Starch is a catalyst.

B Starch acts as a redox indicator.

C Starch is a reducing agent.

D Starch is an oxidising agent.

3. 20.0 cm^3 of a solution of iron(II) chloride needed an average titre of 1 solution of potassium dichromate to reach the end point. What was solution? Relevant half equations are given below.

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}$$
$$Cr_2O_7^{2-}(aq) + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$$

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}

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

Half cell				Standa
$2H^+(aq)$	+	$2e^-$	$\rightleftharpoons$	$H_2(g)$
$Ag^+(aq)$	+	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 electroc
standard hydrogen electrode as the anode and a piece of copper dipp
solution of copper(II) chloride as the cathode.

Half cell					Standa
$2H^+(aq)$	+	$2e^-$	⇌	$H_2(g)$	
$Cu^{2+}(aq)$	+	$2e^-$	⇌	$Cu(s)$	
$Cu^{2+}(aq)$	+	e^-	⇌	$Cu^+(aq)$	

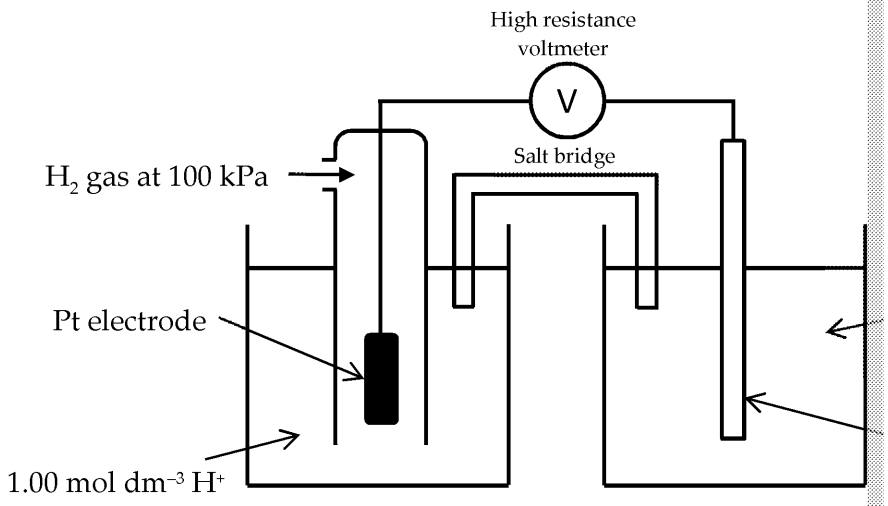
A 0.15 V

B 0.34 V

C -0.15 V

D -0.34 V

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



Her lab partner says that what has been measured is not a *standard* e
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. One type of fuel cell uses the reaction of methanol with oxygen to pr
equation for the reaction in the fuel cell and the half equation for the

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

Which of these is the correct half equation for the reaction at the cath
that it will combine with the anode half equation to form the overall
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 $O_2 + 4H^+ + 6e^- \rightarrow 2H_2O$

Topic 10: Transition Elements

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

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

B $[Ar]3d^4 4s^2$

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

D $[Kr]3d^4 4s^2$

2. Which of the following are correct descriptions of $Pt(NH_3)_2Cl_2$? 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

3. What is the name of the type of reaction shown below?

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

A Ligand substitution

B Precipitation

C Redox

D Chelation

4. Which of these is a correct definition of a *transition element*?

A An element in the d block of the periodic table

B An element in the d block of the periodic table which has colour

C An element in the d block of the periodic table which can exist in

D An element in the d block of the periodic table which has at leas incomplete d subshell

5. When manganese dioxide powder is added to a solution of hydroge evolved. Which statement best explains this observation?

A The manganese dioxide acts as a catalyst causing the rate of oxy increase.

B The manganese dioxide acts as an oxidising agent causing the hy produce oxygen.

C The manganese dioxide acts as a reducing agent causing the hyd produce oxygen.

D The manganese dioxide is oxidised by hydrogen peroxide, conve oxygen.

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

A A precipitate of $Fe(OH)_3$ would form and then disappear as mor precipitate of $Cr(OH)_3$ would form and this too would disappea added.

B A precipitate of $Fe(OH)_3$ would form and would be unaffected b NaOH; a precipitate of $Cr(OH)_3$ would form but would disappea added.

C A precipitate of $Fe(OH)_3$ would form and would be unaffected b NaOH; a precipitate of $Cr(OH)_3$ would form and also be unaffec added.

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

7 Dimethylglyoxime is a bidentate ligand with the formula $C_4N_2O_2H_8$ t DMGH. Which of the following equations best describes the reaction manganese(II) nitrate with DMGH?

A $Mn^{2+}(aq) + DMGH(aq) \rightarrow Mn(DMGH)^{2+}(aq)$

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

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

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

8. Which of the following statements *most fully* describes what happens of potassium iodide is added to a solution of copper(II) sulfate?

A The blue solution becomes colourless and a white precipitate of c

B The colourless solution becomes blue as copper(I) iodide is form

C The blue solution becomes cloudy and brown in colour as iodine copper(I) iodide precipitates.

D The colourless solution becomes brown as iodine forms.

9. Cis-platin is a complex ion with the formula $Pt(NH_3)_2Cl_2$. Which of t completely correct?

A Cis-platin is tetrahedral and used as an anticancer drug.

B Cis-platin is tetrahedral and used to catalyse the hydrogenation c

C Cis-platin is square planar and used as an anticancer drug.

D Cis-platin is square planar and used to catalyse the hydrogenati

Topic 11: Qualitative Analysis

1. Which of the following steps are not performed as part of an accurate in solution?

1: Add barium nitrate and filter to remove any precipitate.
2: Add nitric acid and silver nitrate.
3: Acidify with hydrochloric acid.

A 1 and 2

B 1 and 3

C 3 only

D 1, 2 and 3

2. When sodium hydroxide solution is added to an unknown solid, a g damp red litmus paper blue. Which ion can you say is present in the

A Carbonate ion

B Ammonium ion

C Aluminium ion

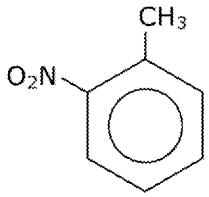
D Sulfate ion

Topic 12: Aromatic Compounds and Electrophil

1. Which of the following pieces of evidence helped to convince the scien
benzene molecules contain a delocalised π-system?

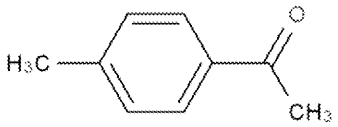
A Less heat energy is absorbed during the hydrogenation of benzene
multiplying the enthalpy of hydrogenation of cyclohexene by three
B Less heat energy is released during the hydrogenation of benzene t
multiplying the enthalpy of hydrogenation of cyclohexene by three
C More heat energy is absorbed during the hydrogenation of benzen
multiplying the enthalpy of hydrogenation of cyclohexene by three
D More heat energy is released during the hydrogenation of benzene
multiplying the enthalpy of hydrogenation of cyclohexene by three

2. What is the name of this molecule?



A 1-methyl-6-nitrobenzene
B 1-nitro-6-methylbenzene
C 1-methyl-2-nitrobenzene
D 1,2-nitromethylbenzene

3. Which of the following sets of reagents would convert methylbenzene



A chloroethane and $AlCl_3$
B chloroethane and sulfuric acid
C ethanoyl chloride and sulfuric acid
D ethanoyl chloride and $AlCl_3$

4. The nitration reaction of methylbenzene requires concentrated nitric a
sulfuric acid. The nitration of phenol can be achieved using just dilute
statements best explains why this is?

A The OH group in phenol withdraws electrons from the delocalised
susceptible to attack by electrophiles.
B The OH group in phenol donates electrons into the delocalised π-s
susceptible to attack by nucleophiles.
C The OH group in phenol donates electrons into the delocalised π-s
susceptible to attack by electrophiles.
D The OH group in phenol withdraws electrons from the delocalised
susceptible to attack by nucleophiles.

5. Phenylamine reacts with bromine water. Which of these is the major p
formed)?

A 2,4,6-tribromophenylamine

B 3,5-dibromophenylamine

C 3-bromophenylamine

D 2,3,4-tribromophenylamine

6. Aromatic compounds can be nitrated using a 'nitrating mixture' of nit
the following equations correctly shows how this mixture reacts to for
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 $2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$

7. Both benzene and phenol can react with bromine, but their reactions a
product of the reaction between aqueous solutions of phenol and bron

A 3,5-dibromophenol

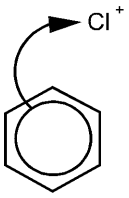
B 4-bromophenol

C 3,4,5-tribromphenol

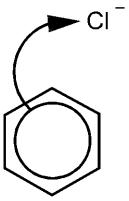
D 2,4,6-tribromophenol

8. Which of these is a correct step in the mechanism of electrophilic subs
halogen in the presence of a halogen carrier?

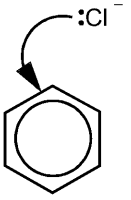
A



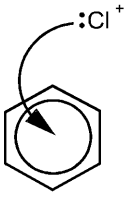
B



C



D



Topic 13: Carbonyl Compounds

1. Which of the following reactions could be used to synthesise propano
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
B 1 and 3
C 1 only
D 1, 2 and 3

2. Which reagent could be used to convert ketones into alcohols?

A NaCN
B NaOH
C $NaBH_4$
D $Na_2Cr_2O_7$

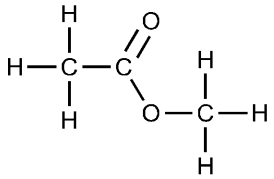
3. A student set up a reaction to convert ethanol into ethanal. Which of t
to tell if the reaction had produced any ethanal or not?

A Add an acidified solution of potassium dichromate to the reaction n
B Add a solution of sodium carbonate to the reaction mixture
C Add a small piece of sodium metal to the reaction mixture
D Add an acidified solution of 2,4-dinitrophenylhydrazine to the rea

4. Which is the correct order of solubility in water from least to most solu

A Propanoic acid, propanal, propene
B Propanal, propene, propanoic acid
C Propene, propanal, propanoic acid
D Propene, propanoic acid, propanal

5. 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

6. Which of the following methods could be used to prepare phenyl etha

1: Mix phenol with ethanoic acid and stir constantly for 15 minutes.
2: Mix phenol with ethanoyl chloride and stir constantly for 15 minu
3: Mix sodium phenoxide with ethanoyl chloride and stir constantly

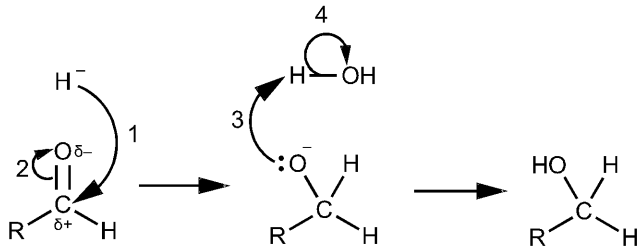
A 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

7. Three organic compounds were tested with Tollens' reagent and then 2,4-dinitrophenylhydrazine. The results are shown in the table below names the functional groups present in the compounds?

Compound	Result of adding Tollens' reagent	Result of ad
1	silver mirror forms	or
2	no reaction	or
3	no reaction	

A compound 1 is an aldehyde; compound 2 is a ketone; compound 3
B compound 1 is a ketone; compound 2 is an aldehyde; compound 3
C compound 1 is an aldehyde; compound 2 is a tertiary alcohol; com
D compound 1 is a tertiary alcohol; compound 2 is an aldehyde; com

8. Which arrow in the following mechanism for the reduction of an aldel



A 1
B 2
C 3
D 4

Topic 14: Nitrogen Compounds

1. Which of the following explains why an amine is basic?

A Amines can donate a nitrogen

B Amines can accept OH^-

C Amines can donate OH^-

D Amines can accept a hydrogen ion

2. Which of the following reactions is the best way to prepare phenylami

A React nitrobenzene with tin and hydrochloric acid

B React benzene with ammonia dissolved in ethanol

C React phenol with ammonia dissolved in ethanol

D React benzene with tin and hydrochloric acid

3. Which of the following is a correct general formula for an amino acid?

A $RCH(OH)COOH$

B $RCH(NH_2^+)COO^-$

C $RCH_2(NH)COOH$

D $RCH(NH_2)COOH$

4. Which of the following compounds has a chiral centre?

A $(CH_3)_2CHOH$

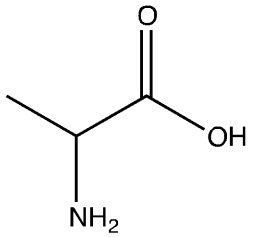
B CH_3CH_2OH

C $CH_3CH_2CH(OH)CH_3$

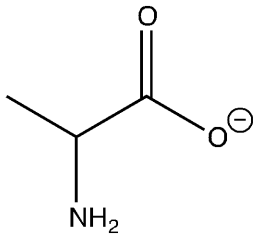
D $(CH_3)_3COH$

5. Which of the following structures is the correct one for the amino acid (in acidic conditions)?

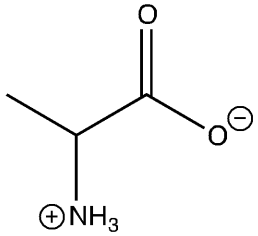
A



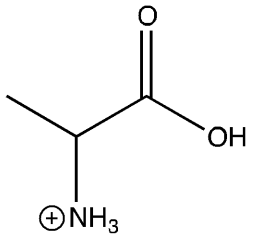
B



C

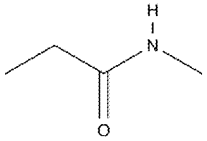


D

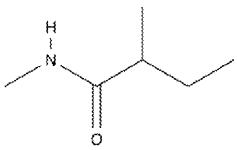


6. Which of the following is a secondary amide with a chiral centre?

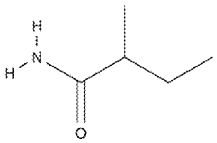
A



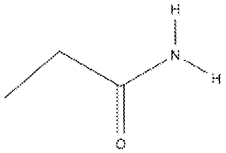
B



C



D



Topic 15: Polyesters and Polyamide

1. Which of the following reactions could produce a polyamide?

A butanedioic acid reacting with hexane-1,6-diol

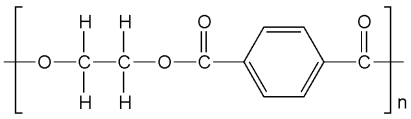
B butanoic acid reacting with hexane-1,6-diamine

C butanedioic acid reacting with hexane-1,6-diamine

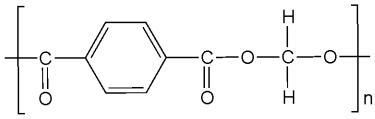
D butanedioic acid reacting with hexylamine

2. Which of the following shows the correct repeat unit of the polymer fo ethane-1,2-diol with benzene-1,4-dicarboxylic acid?

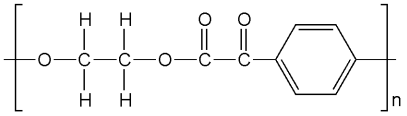
A



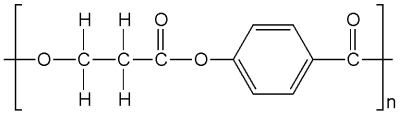
B



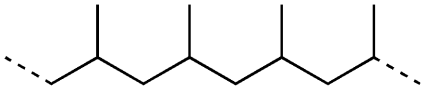
C



D



3. The diagram below shows a section of a polymer chain (containing se monomer or monomers would react to produce this exact polymer?



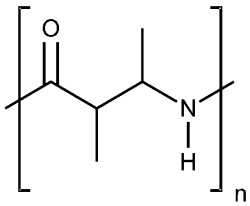
A methane and ethene

B 2-methylprop-1-ene

C 2-methylbut-1-ene

D propene

4. Which of the following functional groups will be produced if this poly under reflux?



A An amine group and a carboxylic acid group

B An ammonium salt and a carboxylic acid group

C An amide group and a carboxylate salt

D An amine group and a carboxylate salt

Topic 16: Organic Synthesis

1. Which of the following is the correct way to synthesise 1-aminopropane (pro

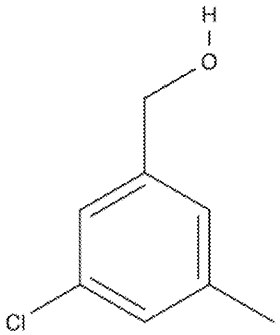
A Reflux chloroethane with sodium cyanide in ethanol then react the hydrogen and a nickel catalyst at high temperature and pressure.
B Heat chloroethane with a large excess of ammonia dissolved in eth then separate the product by distillation.
C Reflux chloroethane with sodium cyanide in ethanol then reflux th hydrochloric acid.
D Reflux chloroethane with a large excess of ammonia dissolved in e product by distillation.

2. Which of the following procedures are used in the purification of an o procedures that can be used.

1: Distillation
2: Recrystallisation
3: Reduced pressure filtration

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

3. How many functional groups are there in the following molecule?



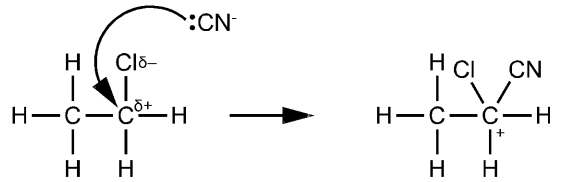
A 1
B 2
C 3
D 4

4. Which of the following correctly describes the process of purifying by solid that is slightly soluble in water?

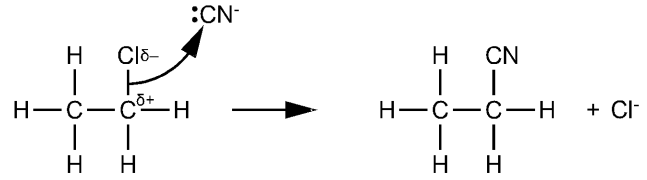
A Dissolve the solid in the minimum amount of cold water; heat the it); if there are any solids left when the solution is hot, filter using a heated glass funnel; cool the solution in ice and filter to collect the
B Dissolve the solid in the minimum amount of hot water; if there ar not dissolve in hot water, filter using a fluted filter paper and heate solution first to room temperature and then in ice, and filter to coll
C Dissolve the solid in the minimum amount of hot water; allow the leaving on the bench for 5 minutes; if any solids have formed, filte paper and heated glass funnel; cool the filtrate in ice, and filter to c
D Dissolve the solid in the minimum amount of cold water; if there a not dissolve in cold water, filter using a fluted filter paper and hea the water (but do not boil it); cool the solution first to room temper and filter to collect the pure product.

5. Which of these correctly represents the reaction between CN^- and chlo

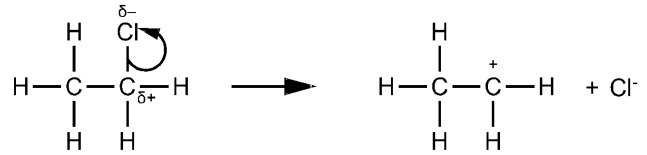
A



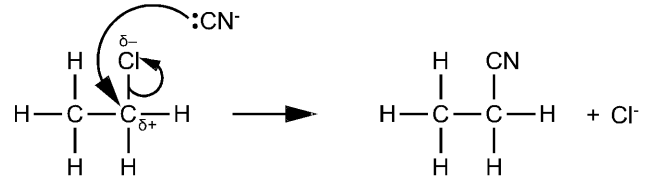
B



C



D



6. Which of the following schemes is a possible way of making 2-hydroxyb

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

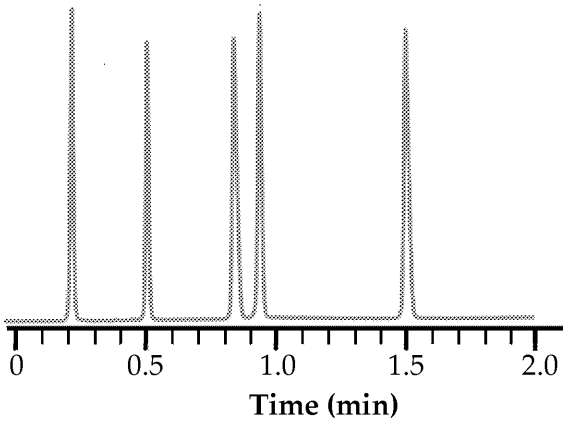
1. $CH_3CH_2CHO \xrightarrow{NaBH_4} CH_3CH_2CH(OH)CH_3$
2. $CH_3CH_2CH(OH)CH_3 \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH(OH)COOH$

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 17: Analysis

1. Use the following gas chromatogram plus the table of data to identify t
the mixture.



Compound	Retention time /min
methanol	0.22
ethanol	0.82
propan-1-ol	1.50
propan-2-ol	1.87
methanal	0.12
ethanal	0.50
propanal	0.95
propanone	1.79

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

2. A student tries to determine the melting point of a solid by performing

The solid is placed into a capillary tube which is inserted into the melt
The temperature is raised until the solid is seen to melt.
Once all of the solid has melted, the temperature is recorded.

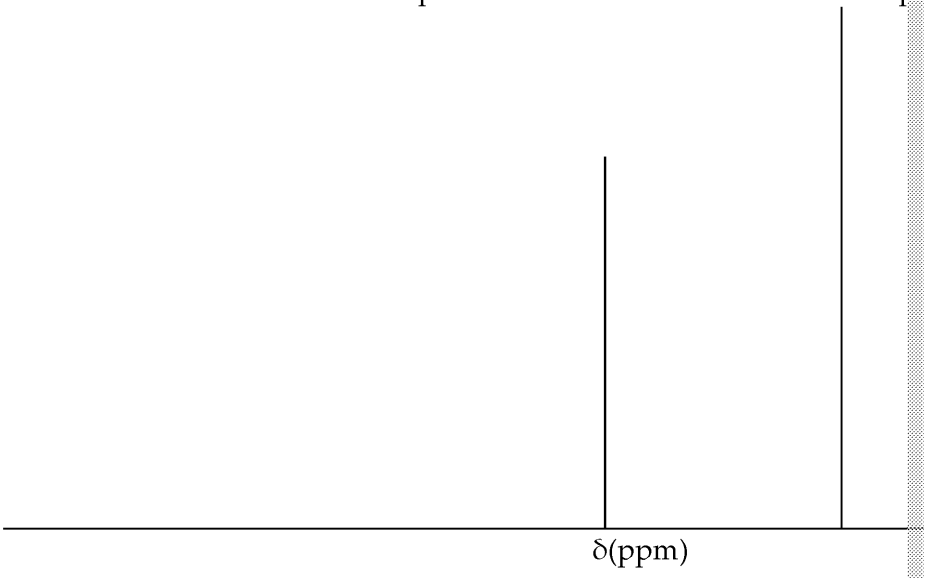
Which of the following points are necessary to achieve an accurate me

1: The capillary tube should be sealed at one end
2: The process should be repeated
3: The melting temperature should be recorded as a range – not a sing

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

3. How many signals would you expect to see in the proton NMR spectr
   A 1
   B 2
   C 3
   D 4

4. 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, $CH_2=CHCH_2OH$
   C prop-1-ene-2-ol, $CH_2=C(OH)CH_3$
   D propanal, CH_3CH_2CHO

5. Which of the following solvents should **not** be used to dissolve a samp
   analysis?
   A $CDCl_3$
   B D_2O
   C CH_3OH
   D $CFCl_3$

Section A Answers

Topic 1: Orders, Rate Equations and Rate Constants

1. B
2. C
3. D
4. C

Topic 2: Rate Graphs and Orders

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

Topic 3: Effect of Temperature on Rate Constants

1. C
2. A

Topic 4: Equilibrium

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

Topic 5: Brønsted–Lowry Acids and Bases

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

Topic 6: Buffers and Indicators

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

Topic 7: Lattice Energies

1. C
2. D
3. B
4. D

Topic 8: Entropy and Free Energy

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

Topic 9: Redox and Electrode Potentials

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

Topic 10: Transition Elements

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

Topic 11: Qualitati

1. C
2. B

Topic 12: Aromatic
Substitution

1. B
2. C
3. D
4. C

Topic 13: Carbonyl

1. B
2. C
3. D
4. C

Topic 14: Nitrogen

1. D
2. A
3. D

Topic 15: Polyester

1. C
2. A

Topic 16: Organic S

1. A
2. C
3. C

Topic 17: Analysis

1. D
2. A
3. B

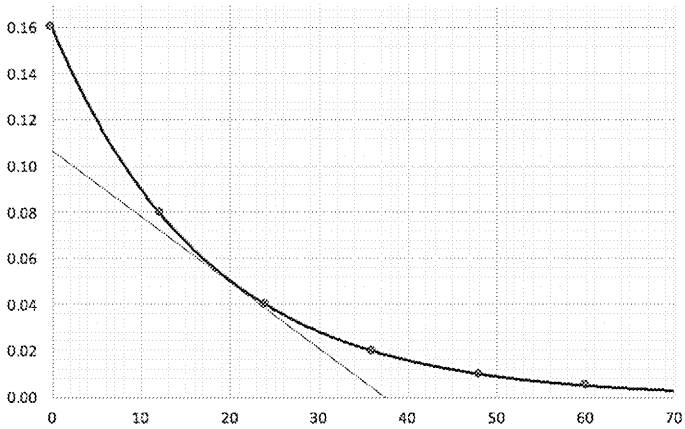
Topic 1: Orders, Rate Equations and Rate C

Question 1			
A	×	Rate equation has been written to include concentration of each reactant as a term	It is possible for rate equation (i. [H+] is zero orde the table of data
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 c table of data – c the rate changes In the same way that as the [H2O2 does the rate – a
C	×	Rate equation has been written to include concentration of each reactant as a term and the stoichiometric coefficients (balancing numbers) have been used as powers	This is an easy m the correct way expression for K to form a rate eq
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 t that the rate **qu** of H_2O_2 change important to see also quadruplin
Question 2			
A	×	Wrong powers for concentration units	It is possible to include concent which cancel wi concentration te
B	×	Powers for concentration units have wrong signs	If the equation is is not well unde reciprocal of a t error to make.
C	✓	Rearranging rate equation gives: **$k = Rate/[A]^2[B]$** Substituting units and cancelling: **$k = \cancel{mol}\ \cancel{dm^{-3}}\ s^{-1}/(mol\ dm^{-3})^2\ \cancel{mol}\ \cancel{dm^{-3}}$** leaving: **$s^{-1}/mol^2\ dm^{-6} = dm^6\ mol^{-2}\ s^{-1}$**	
D	×	Wrong powers and signs for concentration units	This is a combin incorrect answe

Question 3			
A	×	Overall order would be 4	Having three co same as an over
B	×	Overall order would be 4	Having one ter same as an over
C	×	Overall order would be 2	Having a total o constant) each r the overall orde indices of all ter the powers of th considered.
D	✓	The sum of the indices (powers) for the **concentration** terms only = 3	
Question 4			
A	×	$[H_2]$ hasn't been squared	This is the resul
B	×	Equation rearranged wrongly (multiplication instead of division)	This is the resul
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 combi incorrect answe

Topic 2: Rate Graphs and Orders

Question 1			
A	×	Rate increases linearly with [A]	For zero order t… effect upon rate
B	✓	A horizontal line represents zero order in rate–concentration graphs	
C	×	Rate decreases with [A]	For zero order t… effect upon rate
D	×	Rate increases (non-linearly) with [A]	For zero order t… effect upon rate
Question 2			
A	✓	The gradient of a rate–concentration graph gives the value of k. Gradient = $\Delta y/\Delta x$ = 0.7 mol dm^{-3} s^{-1}/0.025 mol dm^{-3} = **28 s^{-1}**	
B	×	This is the reciprocal of the correct answer	Gradient has be… $\Delta x/\Delta y$
C	×	This is wrong by a factor of 10	Decimal point e…
D	×	If k = 0 the reaction would not proceed	The intercept or… instead of the gr… the method of d… factor from a ln …
Question 3			
A	×	This is 1/265	Although consis… of ln 2 has been …
B	×	This is 2/265	Incorrectly reme… and '$t_{½}$' have be… log function (ln)…
C	×	This is ln (2/265)	Error in order o… should be (ln 2)/2
D	✓	If $t_{½}$ = 265 for a first-order reaction, then: k = ln2/265 s = 2.62 × 10^{-3} s^{-1}	
Question 4			
A	×	This is the maximum time shown on graph	Misunderstandi…
B	✓	Reading from the graph between any two values where one is half the other (e.g. 0.16 to 0.08; 0.08 to 0.04; 0.04 to 0.02) – the time between those is consistently 12 s	
C	×	This is the time at which $[O_3]$ = 0.02	Confusion of ha… the digit '2' app… represents half-…
D	×	This is half the maximum time shown on the graph	Confusion of me… that since 70 is t… this is the point … (this is not corre… be half of this ti…

Question 5			
A	×	This is the reciprocal of the correct answer rounded to 2 significant figures	Gradient has be… Δx/Δy
B	×	This is (0.16 – 0.050) mol dm^{-3}/20 s = 5.5 × 10^{-3} mol dm^{-3} s^{-1}	Rather than wo… to the curve, an … calculate the gra… from the graph. **graph were a st… for curves.**
C	×	This is 1/20	A misunderstan… given time (perh… proportional to t… come from read… coincidence tha…
D	✓	 Gradient of tangent to the curve at t = 20 s (see picture) = 0.105 mol d… (Actual value may vary slightly depending on how tangent is drawn… the same when rounded to 2 significant figures.)	

Question 6			
A	×	Technique 1 will work since an acid (HCl) is produced	BUT it is not the … used
B	×	This will work since a gas (N_2) is produced	BUT it is not the … used
C	×	This will work since the reaction is exothermic (temperature will rise as reaction proceeds)	BUT it is not the … used
D	✓	All of the techniques could be used	

Question 7			
A	✓	The rate measured up to the point where the sodium thiosulfate is a… produced causes a colour change) is an approximation of the initial … close to the true initial rate so long as the reaction has not progressed…	
B	×	Second reason is incorrect	For an accurate … important that th… very far when the…
C	×	First reason is incorrect	None of the reac… (the *product*, iodi… that is intensely …
D	×	Both reasons are incorrect	See B and C abo…

Question 8			
A	✗	Wrong powers	The orders (powe correspond to the
B	✗	Wrong formulae	The orders (powe molecularity of th
C	✓	Correct – the orders match the molecularity of the slow (rate determ	
D	✗	Wrong formulae	Only reactants sh equations

Topic 3: Effect of Temperature on Rate C

Question 1			
A	✗	Although k does increase, it is not a linear relationship	Failure to notic exponential
B	✗	k will increase, not decrease, and it is not a linear relationship	Could be an err sign in $-E_a/RT$
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 err sign in $-E_a/RT$
Question 2			
A	✓	Comparing $\ln k = -E_a/RT + \ln A$ to $y = mx + c$ shows that the gradie $-E_a/R$. R is a constant.	
B	✗	This is the wrong graph to plot	A mistake in wh plotted on the y
C	✗	This would give $-E_a$ not E_a	A sign error: E_a cannot be negat
D	✗	This is the wrong graph to plot	A mistake in wh plotted on the y

Topic 4: Equilibrium

Question 1			
A	✗	Not all statements are true	Stater partia
B	✗	Statement 2 is not correct	
C	✓		
D	✗	Statement 3 is correct, but so is statement 1	
Question 2			
A	✓	$K_c = [H_2][I_2]/[HI]^2$ Correctly rearranged: $[HI] = \sqrt{\frac{[H_2][I_2]}{K_c}} = \sqrt{\frac{(1.95\times10^{-3})^2}{0.0215}} = 0.0133 \text{ mol dm}^{-3}$	
B	✗	$K_c = [H_2][I_2]/[HI]^2$ Correctly rearranged: $[HI] = \sqrt{\frac{[H_2][I_2]}{K_c}} = \sqrt{\frac{1.95 \times 10^{-3}}{0.0215}} = 0.301 \text{ mol dm}^{-3}$	Correc rearra substi single
C	✗	$K_c = [H_2][I_2]/[HI]^2$ $[HI] = ([H_2][I_2]/K_c) = ((1.95\times10^{-3})^2/0.0215)$ $= 1.77 \times 10^{-4} \text{ mol dm}^{-3}$	Incorr root)
D	✗	$K_c = [HI]^2/[H_2][I_2]$ $[HI] = \sqrt{K_c \times [H_2][I_2]} = \sqrt{0.0215 \times (1.95\times10^{-3})^2} = 2.86 \times 10^{-4} \text{ mol dm}^{-3}$	Equat ([reac be [pr
Question 3			
A	✗	All three techniques can be used	Titrat that s but al
B	✗	All three techniques can be used	Use o or bas equili not sp
C	✗	All three techniques can be used	Color techni deter
D	✓	All three techniques can be used	
Question 4			
A	✗	There are two types of error	The fr be pr have
B	✗	Powers are missing	The fr produ not be
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 fr be pr

Question 5			
A	✗	[Ag_2SO_4] should not be in the fraction	Conc and s
B	✓	Correct expression – only solutions have concentration terms and the powers are correctly taken from the balanced equation	
C	✗	[Ag_2SO_4] should not be in the fraction [SO_4^{2-}][Ag^+] should be the numerator not the denominator	Conc and s The f prod are n exam
D	✗	Powers are missing	Stoic from used
Question 6			
A	×	Units not cancelled correctly	This what units some
B	×	Units not cancelled correctly	Thes num
C	×	Units not cancelled correctly	Thes deno only.
D	✓	The correct expression for Kc is [Sn^{4+}][Fe^{2+}]^2/[Sn^{2+}][Fe^{3+}]^2. Hence all of th (same total power in numerator as in denominator).	
Question 7			
A	×	Not all statements are correct	It is valu Alth equi as p valu
B	×	Not all statements are correct	Cata equi the reac
C	✓	Only temperature affects the value of equilibrium constants	
D	×	The effect of temperature is incorrect	This -ve) decr

Topic 5: Brønsted–Lowry Acids and B

Question 1			
A	×	Statement 1 is wrong	Brønsted–Lowr
B	×	Statement 1 is wrong	
C	✓	There are other definitions of acids and bases (e.g. Lewis); conjugat one strong and one weak acid or base	
D	×	Statements 2 and 3 are correct (see above)	
Question 2			
A	✓	H_3PO_4 can donate a total of three moles of H^+ ions per mole of H_3PO	
B	×	CH_3COONa	This is a salt, ar
C	×	HNO_3 is not tribasic	HNO_3 can only *mono*basic
D	×	NH_3 is not an acid	NH_3 is a proton
Question 3			
A	×	ions are shown incorrectly	$CaCO_3$ cannot b is a solid
B	✓	All solutions (aq) have been written as separate ions, and the chlori in identical form on both sides of the equation) have been removed	
C	×	spectator ions still present	Cl^- ions are spe
D	×	ionic forms are incorrect and spectator ions present	$CaCO_3$ cannot b is a solid; Cl^- io
Question 4			
A	✓	Since $K_a = [H^+][A^-]/[HA]$ and $[H^+] = [A^-]$	
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 (I fraction (the nu
Question 5			
A	×	1 is correct – but not the **only** correct statement	As with all equ of K_a indicate th further right
B	×	1 and 2 are correct – but not the **only** correct statements	Since $pK_a = -\log$
C	×	2 and 3 are correct – but not the **only** correct statements	
D	✓	All statements are correct	K_a can never be concentration m can take negati
Question 6			
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 ca
Question 7			
A	✓	[monobasic acid] = [H+] = $10^{-pH} = 10^{-1.3} = 0.050$ mol dm^{-3} (to 2 signifi	
B	×	wrong sign in calculation	$10^{+1.3} = 20$ (to 2 s
C	×	wrong formula used	log (1.3) = 0.11 (
D	×	wrong formula used	10 × 1.3 = 13

Question 8			
A	×	pOH has been calculated	pOH = -log(2.5
B	×	sign error	should be pH =
C	×	wrong value	power taken di using log
D	✓	$[H^+] = K_w/[OH^-] = 1 \times 10^{-14}/2.5 \times 10^{-3} = 4 \times 10^{-12}$; pH = -log($4 \times 10^{-12}$) =	
Question 9			
A	×	Wrong value	The concentrati (this is the pH c
B	✓	Using the approximation $[CH_3COOH]_{equilibrium} \sim [CH_3COOH]_{undissocia}$ then $pH = -\log\left(\sqrt{[CH_3COOH] \times K_a}\right) = -\log\left(\sqrt{0.10 \times 1.76 \times 10^{-5}}\right) =$	
C	×	Wrong value	Square root has
D	×	Wrong value	This is the pKa
Question 10			
A	×	Wrong order	Phenol is the w
B	×	Wrong order	Phenol is the w
C	×	Wrong order	Methanoic acid acid
D	✓	Converting all the values to the same type reveals the order (e.g. co and pK_a for phenol to pH of 1 mol dm^{-3} solution)	
Question 11			
A	×	Correct formula, but it is a strong base	Conjugate base
B	✓	Correct formula and strength for the conjugate base	
C	×	Wrong formula and strength for the conjugate base	If this formed it not a base
D	×	Wrong formula	If this formed it not a base

Topic 6: Buffers and Indicators

Question 1			
A	✓	Since sodium hydroxide reacts with methanoic acid to form sodiu essentially a weak acid plus a salt of that acid, and, as such, will fo the weak acid is in excess.	
B	✗	2 is not a buffer solution	Sulfuric acid is
C	✗	Neither 2 nor 3 are buffers	3 will not form different acid
D	✗	There is one mixture that will form a buffer	
Question 2			
A	✗	Wrong value	Wrong formula [acid]/[salt])
B	✓	$[H^+] = K_a \times [acid]/[salt] = 6.46 \times 10^{-5} \times 0.50 = 3.23 \times 10^{-5}$. pH = -log(3.2 places	
C	✗	Wrong value	Concentrations used in the calc
D	✗	Wrong value	Wrong formula
Question 3			
A	✗	Wrong definition	Buffers can only chemical circun
B	✗	Wrong definition	It is not maintai buffers
C	✓	Correct – buffers are equilibria systems that can adjust to compens base	
D	✗	Wrong definition	It is not the abil buffer
Question 4			
A	✗	Wrong base	The titration cu
B	✓	Correct – the diagram relates to a weak acid / strong base titration. high starting pH and a less sharp approach to the equivalence poi neutralisation, ending in a very high pH.	
C	✗	Wrong acid and base	The titration cu strong base
D	✗	Wrong acid	The titration cu
Question 5			
A	✓	Since this is a strong acid / weak base titration, the indicator needs values, as this is where the equivalence point will fall.	
B	✗	Wrong indicator – pH range is unsuitable and will cause an error	This colour cha ammonia (or sli be added than t
C	✗	Wrong indicator – pH range is unsuitable and will cause an error	This colour cha ammonia (or les than the true eq
D	✗	Wrong indicator – pH range is unsuitable and will cause an error	This colour cha ammonia (or les than the true eq

Topic 7: Lattice Energies

Question 1			
A	✗	Wrong use of gas phase and of molar quantity	
B	✗	Wrong use of gas phase	The ions, not th… gas phase. The … standard condit…
C	✓	Correct definition – energy is measured per mole of compound an… energy released in *forming* an ionic lattice	
D	✗	Wrong use of molar quantity	The term is defi… formed
Question 2			
A	✗	Sign error	Breaking the lat… hydration entha…
B	✗	Sign error	The reverse of f… lattice) must be …
C	✗	Wrong value	There are **2** mol…
D	✓	$\Delta_{sol}H(CaBr_2) = -1650 + (2 \times -337) + 2176 = -148$ kJ mol^{-1}	
Question 3			
A	✗	Not the smallest or most highly charged ion	Rb^+ and I^- are la…
B	✓	MgO has both the highest charges on the ions (2+ and 2-) and the s… strongest electrostatic attraction, and, therefore, the most energy w… forms.	
C	✗	Not the smallest ions	Ca^{2+} ion is bigge…
D	✗	Not the smallest or most highly charged ion	Cl^- is less highly … O^{2-}
Question 4			
A	✗	Wrong equation	Na should lose …
B	✗	Wrong states	Ionisation is def…
C	✗	Wrong equation and states	A combination …
D	✓	A gas-phase Na atom loses one electron to form an ion with a posi…	

Topic 8: Entropy and Free Energy

Question 1			
A	✓	The solid state represents a lower state of entropy than aqueous, w	
B	✗	Wrong order	A gas will alwa
C	✗	Wrong order	Solids have leas
D	✗	Wrong order	Solids are lower
Question 2			
A	✗	Wrong value	There are 2 mol
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 3			
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 4			
A	✗	Wrong reasoning	ΔG is negative f
B	✓	Even if thermodynamics predict a reaction is feasible, the rate may	
C	✗	Wrong reasoning	Room temperat conditions
D	✗	Wrong reasoning	Negative values reactions have t feasible

Question 1			
A	✗	Reactants/products mixed up and balancing wrong	You cannot simply
B	✗	Balancing wrong	The electrons must
C	✓	$2MnO_4^- + \cancel{16}\ 6H^+ + 5H_2O_2 + \cancel{10e^-} \rightarrow 2Mn^{2+} + 8H_2O + 5O_2 + \cancel{10H^+} + \cancel{10e}$	
D	✗	Wrong equations	H_2O_2 is different fr
Question 2			
A	✗	Wrong answer	Starch is not a catal
B	✓	Correct. Starch forms an intensely coloured (blue-black) complex point easier to detect	
C	✗	Wrong answer	Starch is not a redu
D	✗	Wrong answer	Starch is not an oxi
Question 3			
A	✗	Value is not a concentration	The number of mol calculated – but no (need to divide this dm^3)
B	✓	Calculation is correct	
C	✗	Wrong concentration	The reacting ratio (account
D	✗	Wrong concentration	The concentration o been scaled up by a volumes of the two accounted for
Question 4			
A	✓	The cell potential would be 0.80 V – -0.76 V = 1.56 V	
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 Cu
B	✓	Since the standard hydrogen electrode has an electrode potential o V = 0.34 V	
C	✗	Wrong half cell and wrong sign	The cell involves Cu
A	✗	Wrong sign	

Question 6			
A	✗	Hydrogen gas is at standard pressure	Bubbling into an op 1 atm – which is sta
B	✓	Standard temperature is 298 K (25 °C), not 293 K (20 °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 solutio mol dm^{-3}, but for tw just need to be equa
A	✗	Hydrogen ion concentration is standard	1 mol $dm^{-3}$is the sta
Question 7			
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 e does not add to the overall equation (th instance)
C	✗	Mass balance is wrong	There are more O a the right of this equ
A	✗	Charge balance is wrong	There is an overall c with 0 on the right

Topic 10: Transition Elements

Question 1			
A	✓	This is correct even though the 4s level is not full – it is the most st	
B	✗	Wrong outer shell configuration	Even though th lowest energy c
C	✗	Wrong inner shell configuration	The core electro [Ar]
D	✗	Wrong inner and outer shell configurations	
Question 2			
A	✗	Wrong shape	It is a square pl
B	✗	Not the only correct answer	There is *cis-tran*
C	✓	It is a four-fold coordination complex with *cis-trans* isomerism	
D	✗	Wrong shape	It is a square pl
Question 3			
A	✓	The water ligands are being replaced by chloride ion ligands	
B	✗	Incorrect description	No solid is form
C	✗	Incorrect description	There is no cha the reactants
D	✗	Incorrect description	There are no mu
Question 4			
A	✗	Incomplete definition	Not all d-block
B	✗	Wrong definition	Colour is a typi compounds but
C	✗	Wrong definition	Variable oxidat transition eleme
D	✓	Correct and complete definition	
Question 5			
A	✓	It is the catalytic behaviour that increases the rate of decompositio for it to become noticeable	
B	✗	Wrong explanation	Hydrogen pero agent to decom
C	✗	Wrong explanation	Hydrogen pero agent to decom
D	✗	Wrong explanation	The oxygen con not the mangan
Question 6			
A	✗	Observation for Fe^{3+} is wrong	$Fe(OH)_3$ does n
B	✓	Correct observation for both Fe^{3+} and Cr^{3+}	
C	✗	Observation for Cr^{3+} is wrong	$Cr(OH)_3$ reacts $[Cr(OH)_6]^{3-}$ – w
D	✗	Observation for both is wrong	$Fe(OH)_3$ does n but $Cr(OH)_3$ do

Question 7			
A	✗	Wrong formulae	Complexes mus substitution equ
B	✗	Wrong formulae	Mn^{2+} forms an i
C	✓	All formulae correct – all six water ligands replaced by three DMG	
D	✗	Wrong equation	Three water liga
Question 8			
A	✗	Incomplete	The blue colour precipitate form formation of str forms a brown s excess iodide io
B	✗	Incorrect	Copper(II) sulfa solutions are co
C	✓	This is the most complete of all of the descriptions	
D	✗	Incorrect	Copper(II) sulfa
Question 9			
A	✗	Wrong geometry	Cis-platin is squ
B	✗	Wrong geometry and use	Cis-platin is squ catalyst
C	✓	This is the correct geometry and the correct use	
D	✗	Wrong use	Cis-platin is not

Topic 11: Qualitative Analysis

Question 1			
A	✗	Both steps are necessary	Step 2 is a good white precipitat nitric acid remo
B	✗	One step is necessary	Step 1 removes false positive re sulfate can be m
C	✓	Adding hydrochloric acid will guarantee that chloride ions are fou	
D	✗	Two steps are necessary	See above
Question 2			
A	✗	Wrong ion	CO_3^{2-} ions do n
B	✓	The alkali causes ammonia gas to be given off	
C	✗	Wrong ion	Al^{3+} ions do not gas
D	✗	Wrong ion	SO_4^{2-} ions do n

Topic 12: Aromatic Compounds and Electrophil

Question 1			
A	✗	Error in statement	The enthalpy o
B	✓	This indicates that benzene is more stable than if it had three localis	
C	✗	Error in statement	The enthalpy o
D	✗	Error in statement	Delocalisation r hydrogenation
Question 2			
A	✗	Wrong numbering	Always give th
B	✗	Wrong numbering and order of substituents	Always give th put substituent
C	✓	The methyl group is at position 1 in the ring and as the nitro group	
D	✗	Numbers in wrong positions	Numbers shoul
Question 3			
A	✗	Wrong reagent	This would alk
B	✗	Wrong reagent	this is a combir C
C	✗	Wrong reagent	Sulfuric acid ca enable the react
D	✓	This is the Friedel–Crafts acylation reaction with $AlCl_3$ as a halogen	
Question 4			
A	✗	Factual error	The OH group
B	✗	Wrong term	The nitration re electrophiles no
C	✓	A pair of electrons from O can join the π-system. An increase in ele readily attacked by electrophiles.	
D	✗	Factual error and wrong term	A combination
Question 5			
A	✓	The amine group donates electrons to the delocalised π-system. Thi substitution is likely, and directs substitution to the 2-, 4- and 6- po	
B	✗	Wrong positions and number of substituents	Most likely pro 2-, 4- and 6-
C	✗	Wrong positions and number of substituents	Most likely pro 2-, 4- and 6-
D	✗	Wrong positions	Substitution is
Question 6			
A	✗	Wrong products	The nitrating el ion
B	✗	Charges missing	The charges do right)
C	✗	Wrong products	$H_2NO_3^+$ may be final product
D	✓	NO_2^+ is the correct electrophile – and the equation is correctly balan	
Question 7			
A	✗	Wrong degree and positions of substitution	The -OH group directing effect, positions 2-, 4-
B	✗	Wrong degree of substitution	The -OH group tri-substitution
C	✗	Wrong positions of substitution	The -OH group 2-, 4- and 6-
D	✓	Correct degree and positions of substitution	

Question 8		
A	✓	
B	✗	Cl should not be negative as it represents the halogen carrier, which allows Cl to be an electrophile
C	✗	Cl should not donate electrons into the ring, as the ring is electron-dense
D	✗	As above, Cl should not donate electrons into the electron-dense ring

Topic 13: Carbonyl Compounds

Question 1			
A	✗	One wrong reaction	Propanone can
B	✓	Both primary alcohols and aldehydes can be oxidised to carboxylic	
C	✗	Not enough correct reactions	1 will work – bu
D	✗	One wrong reaction	Propanone can
Question 2			
A	✗	Wrong reagent	This would ma
B	✗	Wrong reagent	This would ma
C	✓	$NaBH_4$ is capable of reducing aldehydes and ketones to alcohols	
D	✗	Wrong reagent	This is an oxidi needed
Question 3			
A	✗	Will not tell ethanol and ethanal apart	$Cr_2O_7^{2-}$ ions giv for ethanal
B	✗	Will not detect ethanal	This is a test for
C	✗	Will not detect ethanal	Na will react wi
D	✓	2,4-dinitrophenylhydrazine will produce a precipitate only if there present	
Question 4			
A	✗	Wrong order	Propanoic acid
B	✗	Wrong order	Propene is the l
C	✓	Propene is non-polar and insoluble, propanal has no O–H groups, propanoic acid can hydrogen bond with water, making it soluble	
D	✗	Wrong order	Propanoic acid
Question 5			
A	✓	Hydrolysis of an ester with an alkali forms a salt. The carbonyl pa carbons, so the salt will have two carbons (and the alcohol, one).	
B	✗	Incorrect products	Wrong alcohol
C	✗	Incorrect products	Hydrolysis wit
D	✗	Incorrect products	Hydrolysis wit
Question 6			
A	✗	Reaction will not proceed	Phenol does no with carboxylic
B	✗	Only one of these will work	Phenol does no with carboxylic
C	✓	Acyl chlorides are much more reactive than carboxylic acids and c ions	
D	✗	Only two of the three will work	Phenol does no with carboxylic
Question 7			
A	✓	Only an aldehyde will give positive results with both tests; tertiary results in both tests	
B	✗	Compounds 1 and 2 are wrong	Aldehydes give
C	✗	Compounds 2 and 3 are wrong	Ketones give pr dinitrophenylh
D	✗	All are wrong	Ketones give pr dinitrophenylh aldehydes give

Question 8		
A	✓	Arrow 1 is incorrect, because it does not begin at a lone pair or negative charge. All curly arrows must begin at either a lone pair, a charge or a covalent bond.
B	✗	Arrow 2 is correct – it goes from a covalent bond to an atom
C	✗	Arrow 3 is correct – it goes from a lone pair to an atom
D	✗	Arrow 2 is correct – it goes from a covalent bond to an atom

Topic 14: Nitrogen Compounds

Question 1			
A	✗	Untrue	
B	✗	Untrue	
C	✗	Untrue	
D	✓	The lone pair on nitrogen can accept a proton (hydrogen ion)	
Question 2			
A	✓	The NO_2 group will be reduced to NH_2	
B	✗	Reaction will not proceed	Ammonia is not a go
C	✗	Reaction will not proceed	Ammonia is not a go
D	✗	Reaction will not proceed	There is nothing for t
Question 3			
A	✗	Wrong formula	Amino acids have an
B	✗	Wrong formula	For the amine group a proton to become N
C	✗	Wrong formula	This would require fi
D	✓	This is the general formula of amino acids	
Question 4			
A	✗	No chiral centre	Four different groups centre – there are two
B	✗	No chiral centre	Four different groups centre – both C atoms
C	✓	There are four different groups around one of the C atoms – a meth group, a H atom and a hydroxyl (OH) group	
D	✗	No chiral centre	Four different groups centre – there are thr
Question 5			
A	✗	Not protonated	Under acidic conditio with H^+ ions to form
B	✗	Deprotonated	The OH group would acidic conditions – thi conditions
C	✗	Zwitterion	The zwitterion only e point of the amino ac conditions such as pH
D	✓	At very low pH the NH_2 group would react with H^+ ions to form N protonated	
Question 6			
A	✗	Not chiral	No centre with four d
B	✓	N is secondary; carbon 2 (next to carbonyl) has four different group	
C	✗	Not secondary amide	Only one C attached
D	✗	Not secondary amide; not chiral	Only one C attached groups attached

Topic 15: Polyesters and Polyamid

Question 1			
A	✗	Wrong reactants	This would pro
B	✗	Wrong reactants	A dicarboxylic
C	✓	A dicarboxylic acid and diamine can form a polyamide	
D	✗	Wrong reactants	A diamine is ne
Question 2			
A	✓	Correct structure	
B	✗	Wrong structure of repeat unit	This polymer w ethane-1,2-diol
C	✗	Wrong structure of repeat unit	The carbonyl ca another
D	✗	Wrong structure of repeat unit	Benzene ring ha (should be –C=O
Question 3			
A	✗	Wrong monomers	Methane would
B	✗	Wrong monomer	Although the p not mean the m
C	✗	Wrong monomer	Although the p not mean the m
D	✓	The two carbons connected by the double bond join together, leavi side chain methyl groups in the polymer	
Question 4			
A	✗	The amine group would be protonated	Remember, am
B	✓	Hydrolysis forms a monomer with a carboxylic acid group and an amine group, but the amine group will be protonated in acid	Remember, am
C	✗	The amide group would be hydrolysed, and the carboxylic acid produced is unaffected by acid	Carboxylic acid acid
D	✗	The carboxylic acid produced is unaffected by acid. The amine group would be protonated.	Carboxylic acid acid

Topic 16: Organic Synthesis

Question 1			
A	✓	Step 1 increases the chain length by turning chloroethane into prop nitrile to a primary amine.	
B	✗	Fails to increase the chain length	This would pro
C	✗	Wrong functional group produced	This would pro
D	✗	Reaction would fail entirely	The ammonia w
Question 2			
A	✗	This is not the only correct answer	Recrystallisatio pressure filtrati
B	✗	There is one incorrect procedure	Distillation is us
C	✓	Two correct procedures	
D	✗	There is one incorrect procedure	Distillation is us
Question 3			
A	✗	Too few	All functional g
B	✗	Too few	Don't forget tha functional grou
C	✓	Cl, aromatic ring and OH	
D	✗	Too many	Methyl groups a
Question 4			
A	✗	Very little product will be collected	Once dissolved be difficult to g volume of wate through evapor
B	✓	Correct procedure – any insoluble impurities are removed by hot f stay in solution as the water is cooled	
C	✗	Product will be mistakenly discarded	The hot filtratio solution cools
D	✗	Very little product will be collected	Once dissolved be difficult to g volume of wate through evapor
Question 5			
A	✗	The chlorine should be removed	
B	✗	Arrow should not go from bond to CN	CN is a nucleop from the lone p on the C in the C
C	✗	Chlorine does not leave without presence of a nucleophile	
D	✓	CN^- acts as a nucleophile by attacking the positive-dipole carbon, causing the C–Cl bond to break	

Question 6			
A	✓	Correct reagents	Step 1 – CN^- act partial positive aldehyde Step 2 – HCl pe nitrile, forming is a side produc
B	✗	First step works but second step does not	Step 2 – oxidati the chain
C	✗	Neither step works	Step 1 – $NaBH_4$ chain Step 2 – a secon to a carboxylic a
D	✗	Neither step works	Step 1 – oxidati chain Step 2 – OH car as the carbon d OH^- cannot act

Topic 17: Analysis

Question 1			
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 correc	
Question 2			
A	✓	All three are necessary to ensure the melting point is determined ac machine	
B	✗	Only partly correct	Melting always occu (even if it is very nar
C	✗	Only partly correct	If the capillary tube i run out into the mach
D	✗	Only partly correct	The capillary tube m liquid escaping and t melting point should attempt should be m slowed near the melt
Question 3			
A	✗	Too few	There are two proton
B	✓	There is one signal for the proton on the OH group and one more fo groups	
C	✗	Too many	The three CH_3 group environment
D	✗	Too many	The three CH_3 group environment
Question 4			
A	✓	This is the only structure with just two different chemical environm the spectrum	
B	✗	Too many chemical environments	This structure has thr the spectrum would h
C	✗	Too many chemical environments	This structure has thr the spectrum would h
D	✗	Too many chemical environments	This structure has thr the spectrum would h
Question 5			
A	✗	A suitable solvent	The H atom from chl deuterium, which res and so does not appe
B	✗	A suitable solvent	As above
C	✓	The signal from the H atoms in the solvent would be very large and	
D	✗	A suitable solvent	There are no H (or D It is not necessary for long as there is a stan calibration).

Topic 1: Orders, Rate Equations and Rate C

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}	
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. In the rate equation Rate = $k[H_2O_2][I^-]$, which of the following could b constant, k?

A $dm^{-6}\ mol^2\ s^{-1}$

B $dm^3\ mol^{-1}\ s^{-1}$

C $dm^6\ mol^{-2}\ s^{-1}$

D $dm^{-3}\ mol\ s^{-1}$

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 / mol dm^{-3} min^{-1}
0.260	0.320	0.250

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

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

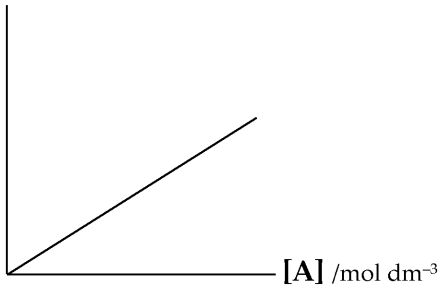
C 0.333 $dm^3\ mol^{-1}\ min^{-1}$

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

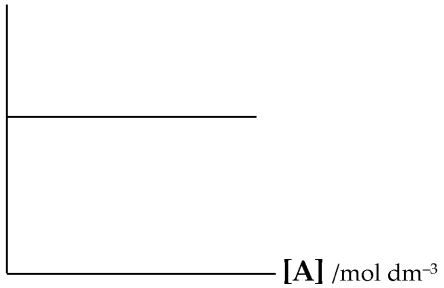
Topic 2: Rate Graphs and Orders

1. If a reaction of a single reactant, A, is first order, which graph represents the rate of reaction against concentration of A?

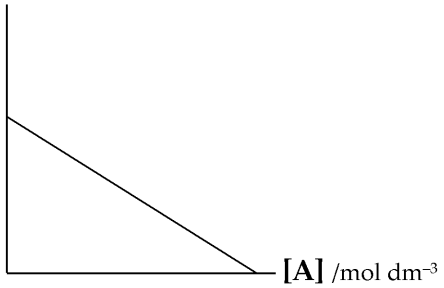
A



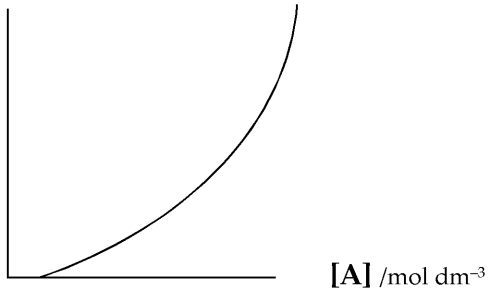
B



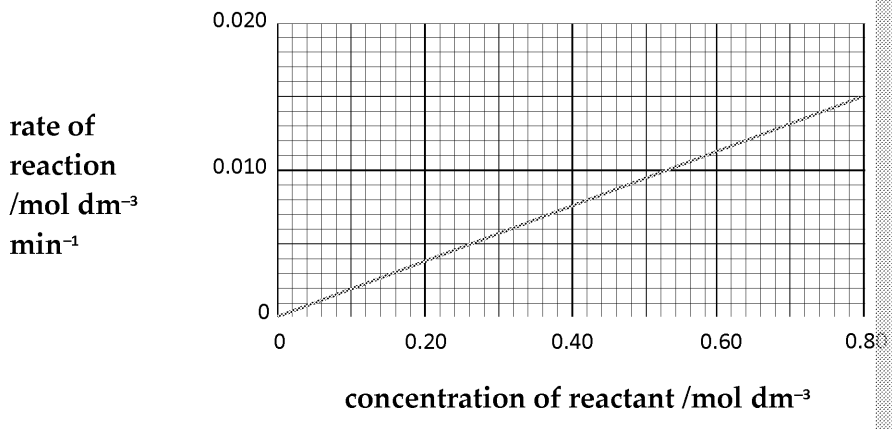
C



D



2. Use the following graph of the rate of a reaction against the concentr
determine the value of the rate constant, k, for the reaction.



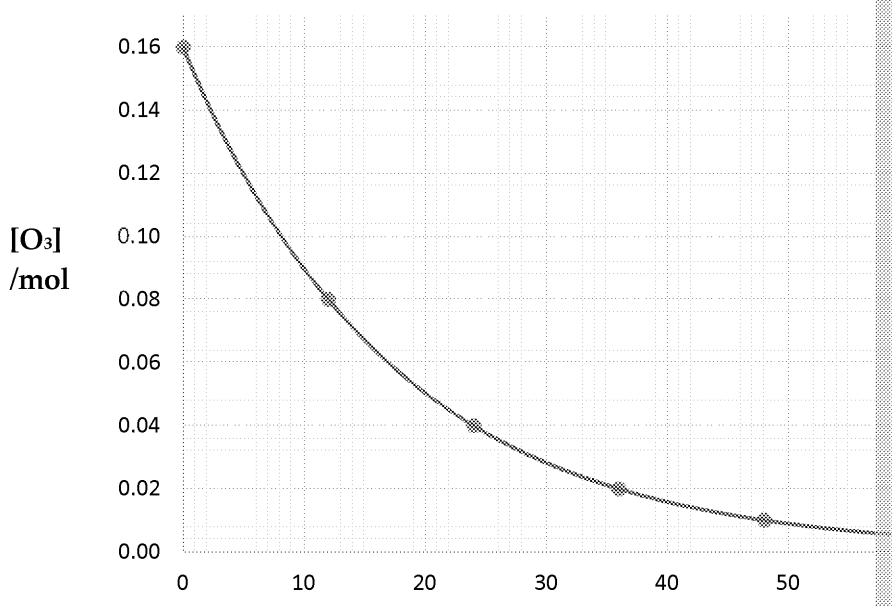
A $k = 0.80\ min^{-1}$

B $k = 0.015\ min^{-1}$

C $k = 53\ min^{-1}$

D $k = 0.019\ min^{-1}$

3. The rate of decomposition of hydrogen peroxide, H_2O_2, to form H_2O a
rate equation: rate = $k[H_2O_2]$. The concentration of hydrogen peroxi
intervals, at a constant temperature, and the data used to produce th
this graph to determine the value for the rate constant, k.



A $0.0909\ s^{-1}$

B $0.0289\ s^{-1}$

C $-2.40\ s^{-1}$

D $3.46\ s^{-1}$

4. The table below shows some data that was collected to study the kin
nitrogen dioxide, NO_2. Use this data to determine which of the follo
order of the reaction and the half-life is true.

Time /s	0	30	60	90	120	
$[NO_2]$ /mol dm^{-3}	0.10	0.079	0.063	0.050	0.040	

A The reaction is first order, with a half-life that changes over the c

B The reaction is second order, with a half-life that changes over th

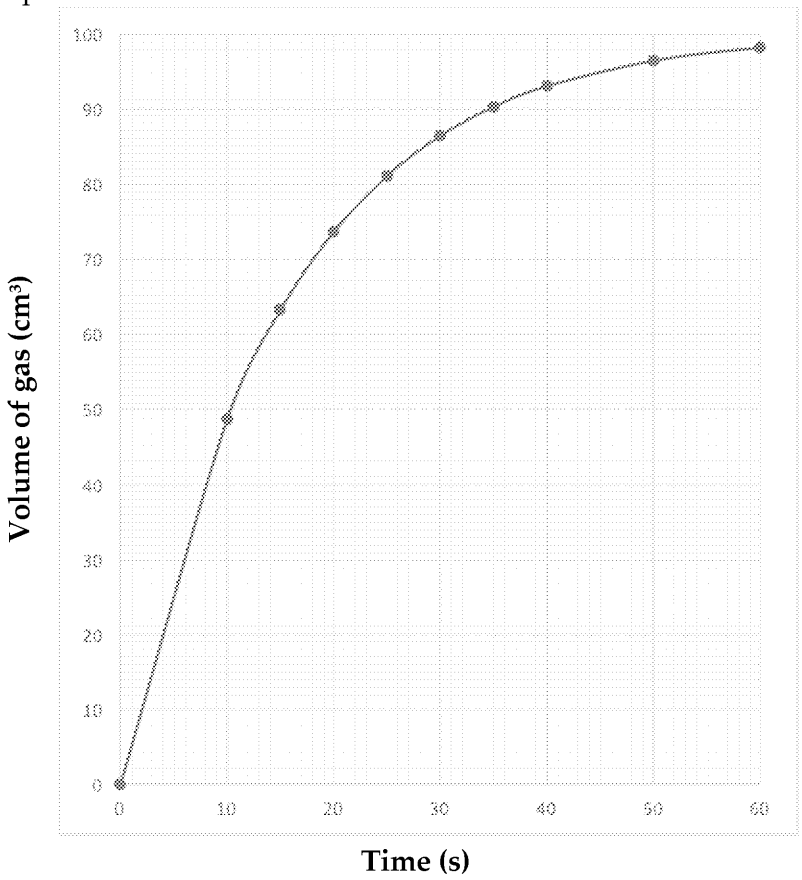
C The reaction is second order, with a constant half-life of 90 s.

D The reaction is first order, with a constant half-life of 90 s.

5. 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 $cm^3\ s^{-1}$

6. Sodium thiosulfate reacts with hydrochloric acid according to the fol

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaC1(aq) + SO_2(g) + S$$

Which of the following techniques could be used to monitor the rate

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

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

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

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

7. The decomposition of hydrogen peroxide, $2H_2O_2 \rightarrow 2H_2O + O_2$, is cat
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 that 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

Topic 3: Effect of Temperature on Rate Co

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

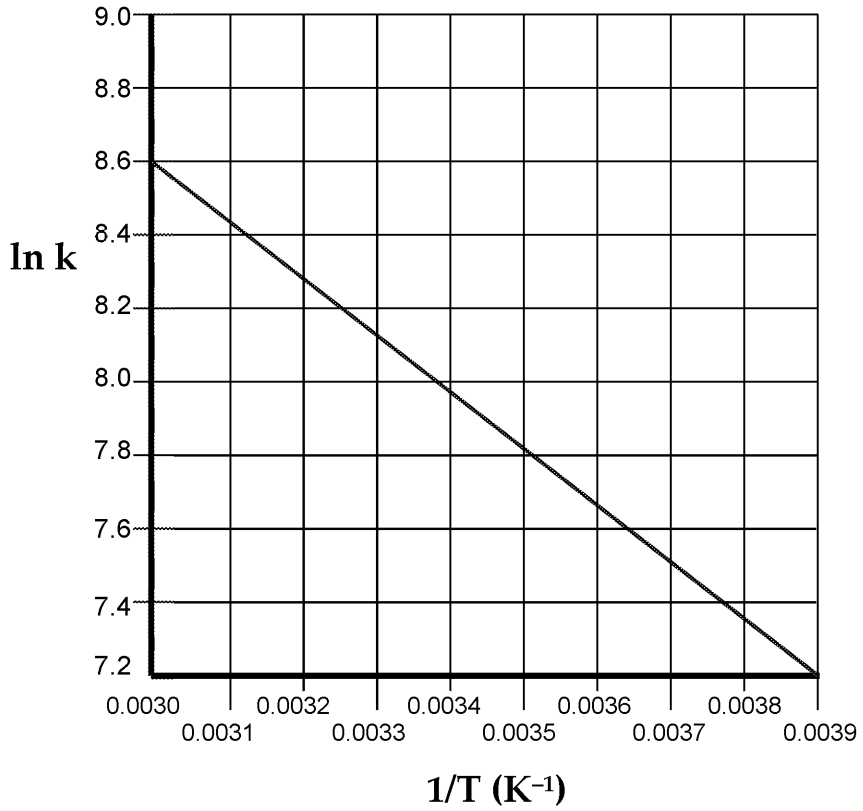
A As T increases, a greater proportion of particles have energy gre increases linearly.

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

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

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

2. The Arrhenius equation can be converted into the following: ln k = -E below to determine the correct values for the activation energy, E_a. T J K^{-1} mol^{-1}



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 4: Equilibrium

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: $\boldsymbol{K_p} = \frac{(P_{NO_2})^2}{P_{N_2O_4}}$

Which of the following statements related to this gas-phase chemical
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. The
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. The
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, incre
pressure of NO_2 and decreasing the partial pressure of N_2O_4. The
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
an equilibrium is established under these conditions, in which it is k
partial pressures of both N_2 and O_2 is 28 kPa, what is the equilibrium

A 882 kPa

B 697 kPa

C 26.4 kPa

D 29.7 kPa

3. The following are pieces of laboratory equipment and their uses:

1: Gas syringe for measuring volumes of gas
2: Colorimeter for measuring intensity of colour in solutions
3: pH meter for measuring pH of solutions

Which of these pieces of equipment could be used to determine an eq
equilibrium shown below?

$$C_6H_6(g) + 3H_2(g) \rightleftharpoons C_6H_{12}(g)$$

A Only 1

B Only 1 and 2

C Only 1 and 3

D 1, 2 and 3

4. A student found a ligand substitution reaction written unconventionally. What is the expression for K_c for the following reaction as it is written?

$$Cu^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{2+}(aq)$$

A $$K_c = \frac{[Cu^{2+}][NH_3]^4}{[Cu(NH_3)_4^{2+}]}$$

B $$K_c = \frac{[Cu(NH_3)_4^{2+}]}{[Cu^{2+}][NH_3]^4}$$

C $$K_c = \frac{[Cu(NH_3)_4^{2+}]}{[Cu^{2+}][4NH_3]}$$

D $$K_c = \frac{[Cu^{2+}][4NH_3]}{[Cu(NH_3)_4^{2+}]}$$

5. Which is the correct expression for K_c for the following reaction?

$$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$$

A $$K_c = \frac{[Pb^{2+}][I^-]^2}{[PbI_2]}$$

B $$K_c = [Pb^{2+}][I^-]^2$$

C $$K_c = \frac{[Pb^{2+}][2I^-]}{[PbI_2]}$$

D $$K_c = [Pb^{2+}][2I^-]$$

6. Which of the following shows the correct units for K_p for the following reaction?

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

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, pressure and the presence of a catalyst affect the follow

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

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 5: Brønsted–Lowry Acids and B

1. The following lists shows pairs of species that may or may not be co

1: CH_3OH and CH_3O^-
2: NH_4^+ and NH_3
3: CH_3COOH and CH_3CHO

Which of these are true conjugate acid–base pairs?

A Only 1

B Only 1 and 2

C Only 2 and 3

D 1, 2 and 3

2. Which of the following is a *monobasic* acid?

A Oxalic acid, HOOC-COOH

B Dimethylamine, $(CH_3)_2NH$

C Phenol, C_6H_5OH

D Ammonia, NH_3

3. Sulfuric acid reacts with calcium hydroxide according to the followi

$$H_2SO_4(aq) + Ca(OH)_2(aq) \longrightarrow CaSO_4(aq) + 2H$$

Which is the correct *ionic* equation for this reaction?

A $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

B $2H^+(aq) + Ca(OH)_2(aq) \longrightarrow Ca^{2+}(aq) + 2H_2O(l)$

C $2H^+(aq) + SO_4^{2-}(aq) + Ca(OH)_2(aq) \longrightarrow CaSO_4(aq) + 2H_2O(l)$

D $2H^+(aq) + SO_4^{2-}(aq) + Ca^{2+}(aq) + 2OH^-(aq) \longrightarrow Ca^{2+}(aq) + SO_4^{2-}(aq) +$

4. Which of the following three equations correctly describes the mathe
K_a and pK_a?

1: $K_a = e^{-pKa}$
2: $K_a = 10^{-pKa}$
3: $\frac{pK_a}{\log K_a} = -1$

A Only 1

B Only 1 and 3

C Only 2 and 3

D 1, 2 and 3

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 concentra

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 *monobasic*, *strong* acid with a concen

A 1.3

B 3.0

C -1.3

D -3.0

7. If a solution of a strong *dibasic* acid has a pH of 1.0, what is the conce

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. Taking the value of K_a for benzoic acid as 6.46×10^{-5} mol dm^{-3}, which correct pH for a solution of benzoic acid with a concentration of 0.20

A 2.09

B 2.44

C 4.19

D 4.75

10. Which is the most useful correct expression for the ionic product of

A $K_w = \frac{[H^+]}{[OH^-]}$

B $K_w = \frac{[H^+][OH^-]}{[H_2O]}$

C $K_w = [H^+][OH^-]$

D $K_w = \frac{[OH^-]}{H^+}$

11. Methylamine is a weak base with the formula CH_3NH_2. Which one correct formula and description for a conjugate acid of methylamin

A $CH_3NH_3^+$, which is a weak acid

B $CH_3NH_3^+$, which is a strong acid

C CH_3NH^-, which is a weak acid

D CH_3NH^-, which is a strong acid

Topic 6: Buffers and Indicators

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

1: A solution of a weak acid mixed with a solution of a strong bas
there are equal numbers of moles of each.
2: A solution of a weak acid mixed with a solution of a salt of tha
that there are equal numbers of moles of each.
3: A solution of a weak acid mixed with a solution of a strong bas
there is an excess of weak acid.

A Only 1

B Only 1 and 2

C Only 2 and 3

D 1, 2 and 3

2. A buffer solution made by mixing equal volumes of ethanoic acid an
solutions, both with a concentration of 0.50 mol dm^{-3}, has a pH of 4.7
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}

3. Blood contains both carbonic acid, H_2CO_3, and hydrogen carbonate i
form a *buffer solution*. Why is this significant to human health?

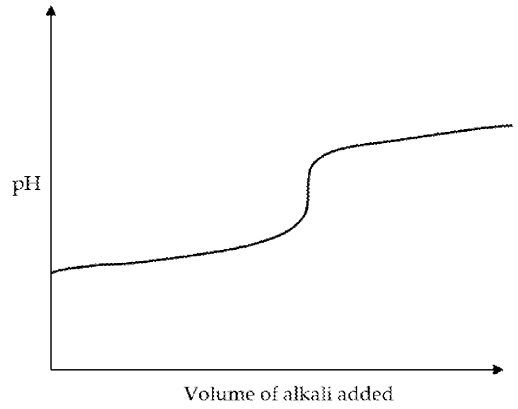
A Carbonic acid and hydrogen carbonate ions can move from the b
organs to neutralise excess acid or alkali that may build up there

B Blood pH needs to be maintained between 7.35 and 7.45 and the
helps maintain a constant pH, even if small amounts of acidic or
the blood.

C Buffer solutions are an important part of our immune system. T
carbonic acid and hydrogen carbonate ions makes it harder for b
blood.

D Hydrogen carbonate ions are necessary for blood to effectively t
buffer maintains a constant concentration of these ions.

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



A Phenol titrated against ammonia

B Phenol titrated against sodium hydroxide

C Hydrochloric acid titrated against ammonia

D Hydrochloric acid titrated against sodium hydroxide

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

Indicator	pH range ove
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

Topic 7: Lattice Energies

1. Which of the following best describes what lattice energy is a measu

A The internal energy of an ionic compound

B The entropy of an ionic compound

C The forces between oppositely charged ions in the gas phase

D The strength of ionic bonding in a lattice

2. Use the data below to calculate the enthalpy of solution for ammoniu

$\Delta_{LE}H$ (NH_4NO_3) = -646 kJ mol^{-1}; $\Delta_{Hyd}H$ (NH_4^+) = -307 kJ mol^{-1}; $\Delta_{Hyd}H$ (

A -25 kJ mol^{-1}

B +25 kJ mol^{-1}

C -1267 kJ mol^{-1}

D +1267 kJ mol^{-1}

3. Based on the data below, which of the compounds has a lattice with

Cation	Radius /pm	Anion	R
Na^+	113	Cl^-	
Rb^+	149	I^-	
Mg^{2+}	72	O^{2-}	
Ca^{2+}	100	S^{2-}	

A $MgCl_2$

B Na_2O

C CaO

D Rb_2S

4. Which of the following equations correctly represents the first electro

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

Topic 8: Entropy and Free Energy

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

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

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

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

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

2. 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}

3. Use the data in the table below to select which of the reactions are fe

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	-
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

4. Apart from a value for ΔG, what other information is necessary in or particular reaction could be used to produce a chemical?

A The entropy change for the reaction

B The enthalpy change for the reaction

C Which catalyst can be used in the reaction

D The rate constant for the reaction

Topic 9: Redox and Electrode Potent

1. Use the two half equations below to select the correctly balanced ove of dichromate ions with iron(II) ions.

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$

A $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

B $6Fe^{3+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{2+} + 2Cr^{3+} + 7H_2O$

C $Fe^{2+} + Cr_2O_7^{2-} + 14H^+ + 5e^- \rightarrow Fe^{3+} + 2Cr^{3+} + 7H_2O$

D $2Cr^{3+} + 7H_2O + 6Fe^{3+} \rightarrow Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+}$

2. When performing acid–base titrations, an indicator is usually require point. In a redox titration in which potassium permanganate, $KMnO_4$ concentration of iron(II) ions in solution, no indicator is necessary. W

A It is more accurate to use a pH meter.

B The appearance of the colour of unreacted potassium permangana

C The disappearance of the colour of iron(II) ions indicates the end

D The end point can only be accurately determined by plotting a g

3. 25.0 cm^3 of a solution of sodium ethanedioate, $Na_2C_2O_4$, needed an a 0.00850 mol dm^{-3} solution of potassium permanganate to reach the e concentration of the sodium ethanedioate solution? Relevant half eq

$2CO_2 + 2e^- \rightleftharpoons C_2O_4^{2-}$
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$

A 0.0331 mol dm^{-3}

B 0.0273 mol dm^{-3}

C 0.00661 mol dm^{-3}

D 0.0165 mol dm^{-3}

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

Half cell				Standa
$Pb^{2+}(aq)$	+	$2e^-$	$\rightleftharpoons$	$Pb(s)$
$Ag^+(aq)$	+	e^-	$\rightleftharpoons$	$Ag(s)$
$Al^{3+}(aq)$	+	$3e^-$	$\rightleftharpoons$	$Al(s)$

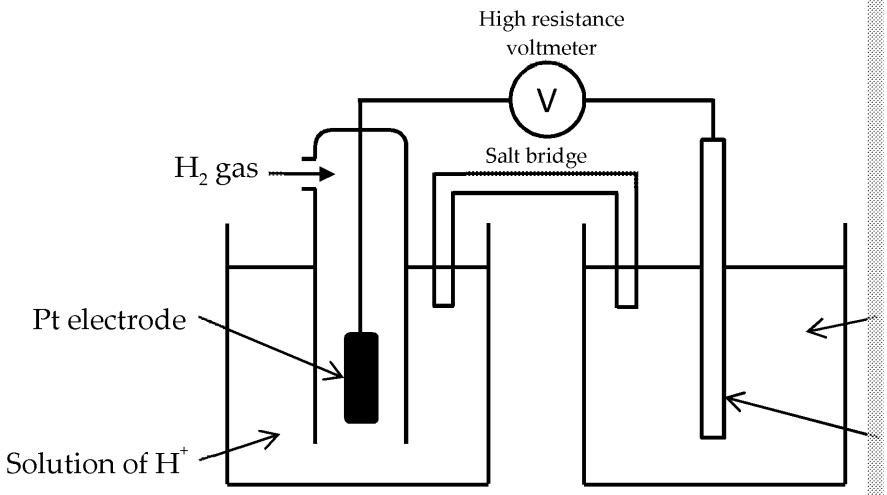
A Pb(s) and $Ag^+(aq)$

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				Standa
$2H^+(aq)$	+ $2e^-$	⇌	$H^2(g)$	
$Co^{2+}(aq)$	+ $2e^-$	⇌	$Co(s)$	
$Co^{3+}(aq)$	+ e^-	⇌	$Co^{2+}(aq)$	

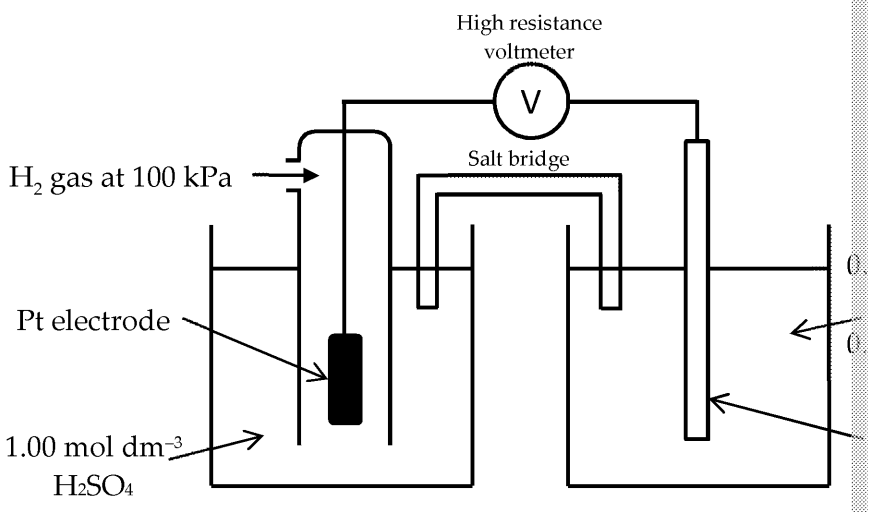
A -0.28 V

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) re
following cell:



Her lab partner says that what has been measured is not a *standard* e
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. A hydrogen fuel cell uses the reaction of hydrogen with oxygen to p
overall equation for the reaction in the fuel cell and the half equation

Overall: $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$
Anode: $H_2 \rightarrow 2H^+ + 2e^-$

Which of these is the correct half equation for the reaction at the cath
that it will combine with the anode half equation to form the overall e
above?

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

B $O_2 + 2H^+ + 2e^- \rightarrow H_2O$

C $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

D $\frac{1}{2}O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

Topic 10: Transition Elements

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

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 be correct descriptions of $Ni(CO)_4$? Give

1: It is a tetrahedral complex ion
2: It has a coordination number of 4
3: It has two optical 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 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 a yellow solution of vanadate(V) ions reacts with zinc metal th
then green as the vanadate(V) ions are converted to vanadium(IV) a

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 of the following statements describes what you would observ
solution was added *dropwise* to separate solutions of copper(II) sulfa

A A precipitate of $Fe(OH)_2$ would form and then disappear as mor
precipitate of $Cu(OH)_2$ would form and this too would disappea
was added.

B A precipitate of $Fe(OH)_2$ would form and would be unaffected b
ammonia; a precipitate of $Cu(OH)_2$ would form but would disap
was added.

C A precipitate of $Fe(OH)_2$ would form and would be unaffected b
ammonia; a precipitate of $Cu(OH)_2$ would form and also be una
ammonia was added.

D A precipitate of $Fe(OH)_2$ would form and then disappear as mor
precipitate of $Cu(OH)_2$ would form but would be unaffected as
added.

7. Bisethylenetriamine is a neutral tridentate ligand that is usually referre
following equations best describes the reaction of an aqueous solution

A $Co^{2+}(aq) + tris(aq) \rightarrow Co(tris)^{2+}(aq)$

B $[Co(H_2O)_6]^{2+}(aq) + 2tris(aq) \rightarrow [Co(tris)_2]^{2+} + 6H_2O$

C $[Co(H_2O)_4]^{2+}(aq) + tris(aq) \rightarrow [Co(tris)(H_2O)_3]^{2+} + H_2O$

D $[Co(H_2O)_6]^{2+}(aq) + 2tris(aq) \rightarrow [Co(tris)_2(H_2O)_4]^{2+} + 2H_2O$

8. Which of the following statements *most fully* describes what happens hydroxide is added to a solution of chromium(III) chloride, followed peroxide with heating?

   A The blue-violet solution becomes green as water ligands are rep and then turns yellow as chromium(III) is oxidised to chromium(

   B The green solution becomes yellow as chromium(III) is oxidised then turns blue as water ligands are replaced by hydroxide ions.

   C The yellow solution produces a green precipitate of chromium(I dissolves when it is oxidised by hydrogen peroxide, forming a b

   D The colourless chromium(III) solution becomes first green, then peroxide is added a yellow precipitate of chromium(VI) oxide fo

9. How does cis-platin act as an anticancer drug?

   A It catalyses reactions that produce cancer-fighting enzymes in th

   B It forms complexes with haem proteins in the bloodstream

   C It absorbs radiation, allowing it to be concentrated in the area of

   D It binds to DNA in cancer cells preventing them from dividing

Topic 11: Qualitative Analysis

1. Which of the following steps are performed as part of an accurate test solution?

1: Add barium chloride
2: Add nitric acid and silver nitrate
3: Acidify with hydrochloric acid

A 1 and 2

B 1 and 3

C 3 only

D 1, 2 and 3

2. When hydrochloric acid is added to an unknown solid, a gas is given milky. Which ion can you say is present in the solid?

A Carbonate ion

B Ammonium ion

C Aluminium ion

D Sulfate ion

Topic 12: Aromatic Compounds and Electrophil

1. Which of the following pieces of evidence helped to convince the scie benzene molecules contain a delocalised π-system?

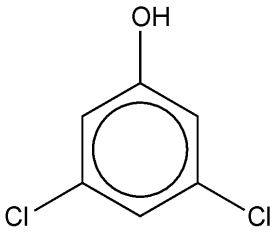
A The C–C bonds in benzene were found to be exactly the same le

B Three of the C–C bonds in benzene were found to be longer thar 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. What is the correct IUPAC name of this molecule?



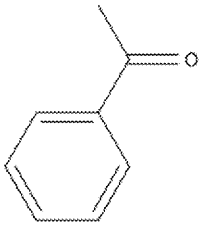
A 3,5-dichlorophenol

B 2,4-dichlorophenol

C 1-hydroxy-2,4-dichlorobenzene

D 1-chloro-3-hydroxy-5-chlorobenzene

3. Which of the following sets of reagents would convert benzene into ph



A chloroethane and $AlCl_3$

B ethanoyl chloride and $AlCl_3$

C chloroethane and sulfuric acid

D ethanoyl chloride and sulfuric acid

4. The reaction of benzene with bromine requires a catalyst, or the reac
The reaction of cyclohexene with bromine is very fast and requires n
these statements best explains why this is?

A Benzene can only be attacked by electrophiles and bromine beha

B Benzene has three C=C double bonds, whereas cyclohexene only
bond; therefore, benzene repels bromine molecules more strong
does.

C Bromine molecules are not attracted to the π-electrons in benzen
attracted to the σ-electrons in cyclohexene.

D The delocalised π-system in benzene makes it very stable and, th
The localised π-bond in cyclohexene makes it less stable and, the

5. Phenol reacts with sodium hydroxide to form sodium phenoxide an
with sodium carbonate at all. Which of the following statements bes

A Phenol is an acid, but only a very weak acid.

B The OH group in phenol donates a pair of electrons to the π-sys
with hydroxide ions.

C Carbonate ions are not electrophiles and do not attack any arom

D The OH group in phenol makes the molecule more reactive so it
nucleophiles such as hydroxide ions.

6. Aromatic compounds can be brominated using a 'halogen carrier' ca
following equations correctly shows how a halogen carrier helps to f
attacks the benzene ring?

A $Br_2 + HNO_3 \rightarrow BrNO_3 + HBr$

B $Br_2 + FeBr_3 \rightarrow Br^+ + FeBr_4^-$

C $3Br_2 + 2Al \rightarrow 2AlBr_3$

D $HBr + HNO_3 \rightarrow NO_2^+ + Br^- + H_2O$

7. What is the product of the reaction between nitrobenzene and excess
halogen carrier catalyst?

A 2,4-dibromonitrobenzene

B 4-bromonitrobenzene

C 3-bromonitrobenzene

D 2,4,6-tribromonitrobenzene

8. Benzene only reacts with bromine in the presence of a halogen carrie
bromine, even if it is diluted in water, with no catalyst present. Whi
explains this observation?

A The lone pair of electrons in a p-orbital on the O atom in phenol
with the π-system of the benzene ring. This makes phenol more
so it reacts with bromine without a catalyst.

B The lone pair of electrons in a p-orbital on the O atom in phenol
with the π-system of the benzene ring. The increased electron d
system makes the ring more reactive and so phenol reacts with b
catalyst.

C Because O is more electronegative than C, the -OH group draws
the ring. The decreased electron density in the delocalised syste
reactive and so phenol reacts with bromine without a catalyst.

D Because O is more electronegative than C, the polar C–O bond c
electron density in the ring. The increased electron density in th
makes the ring more reactive and so phenol reacts with bromine

Topic 13: Carbonyl Compounds

1. Which of the following compounds can be reacted with sodium tetra
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

2. Which reagent could be used to convert secondary alcohols into keto

A NaCN

B NaOH

C $NaBH_4$

D $Na_2Cr_2O_7$ / H^+

3. An unlabelled bottle is known to contain either butanal or butanone.
reagents could be used to tell which compound is in the bottle?

A Tollens' reagent

B Sodium cyanide

C Sodium carbonate

D 2,4-dinitrophenylhydrazine

4. Which of the following statements best describes why carboxylic aci
than aldehydes or ketones?

A There are twice as many O atoms in a carboxylic acid molecule c
or ketone with the same number of carbon atoms.

B Carboxylic acids can form hydrogen bonds; aldehydes and keto

C Water is basic and so reacts with carboxylic acids.

D Aldehydes and ketones do not have as many hydrogen atoms as
the same number of carbon atoms.

5. What is the correct name of the product of the reaction between prop

A Propyl ethanoate

B Propanoyl ethanoate

C Ethyl propanoate

D Ethanoyl propanoate

6. Which of the following reagents could be used to convert propan-1-o

1: Propanoic acid
2: Propanoic anhydride
3: Propanoyl chloride

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

7. Which of the following compounds could be prepared using ethanoy

A Ethyl propanoate

B N-methylethanamide

C Ethyl benzoate

D N-ethylmethanamide

8. By which type of mechanism does a cyanide ion react with a ketone?

A Nucleophilic addition

B Electrophilic addition

C Nucleophilic substitution

D Electrophilic substitution

Topic 14: Nitrogen Compounds

1. In which of the following reactions is there an **amine** behaving as a B

1: $CH_3NH_2 + CH_3COCl \rightarrow CH_3CONHCH_3 + HCl$
2: $CH_3CONH_2 + H_2O + HCl \rightarrow CH_3COOH + NH_4Cl$
3: $CH_3CH_2NH_2 + HCl \rightarrow CH_3CH_2NH_3Cl$

A 3 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

2. Which of the following reactions is the best way to prepare ethylami

A React chloroethane with a molar equivalent of ammonia in aque

B React chloroethane with an excess of ammonia using ethanol as

C React an excess of chloroethane with ammonia in aqueous soluti

D React chloroethane with a molar equivalent of ammonia using e

3. Which of the following is a **secondary amide**?

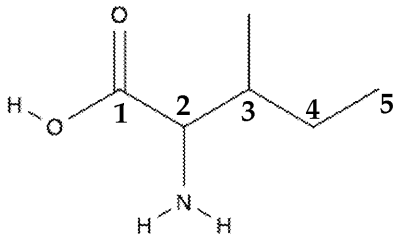
A $(CH_3CH_2)_2NH$

B CH_3CONH_2

C $(CH_3)_2CHCONH_2$

D $CH_3CONHCH_3$

4. The diagram below shows the structure of the amino acid 2-amino-3
called isoleucine). The carbons have been numbered in accordance v
these numbers, identify all of the chiral centres in this molecule.



A 2 only

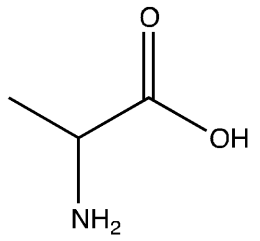
B 1, 2 and 3

C 2 and 3

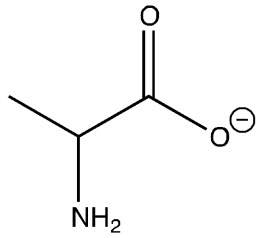
D 2, 3 and 4

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

A



B



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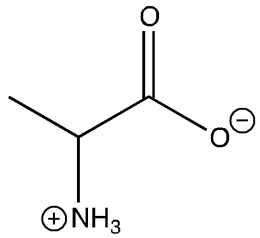

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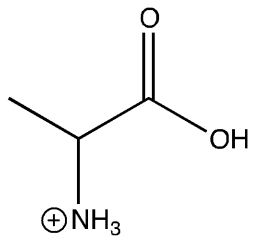


6. Which of the following is the correct general formula for an α-amino

A RCH_2COOH

B $R(NH_2)CH_2$

C $NH_2CH_2RCHCOOH$

D $RCH(NH_2)COOH$

Topic 15: Polyesters and Polyamide

1. Which of the following reactions could produce a polyester?

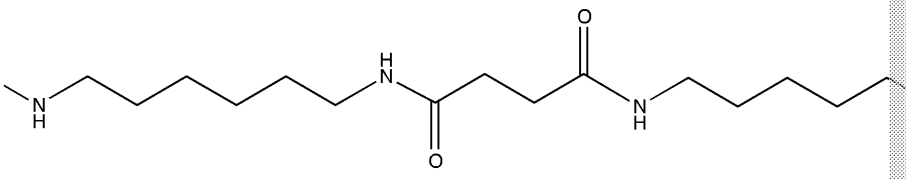
A Benzene-1,4-dicarboxylic acid reacting with ethane-1,2-diol

B Benzenecarboxylic acid reacting with hexane-1,6-diamine

C Benzene-1,4-dicarboxylic acid reacting with hexane-1,6-diamine

D Benzenecarboxylic acid reacting with ethanol

2. The diagram below shows a section of a polymer. Which monomer c formed from?



A Butanamide and hexylamine

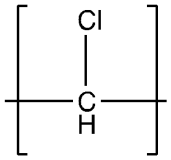
B N-hexylethanamide

C N,N′-dihexylbutanediamide

D Butanedioic acid and hexane-1,6-diamine

3. Which of the following correctly shows the repeat unit of poly(chlor

A



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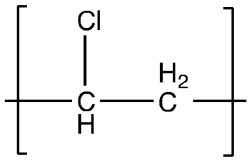

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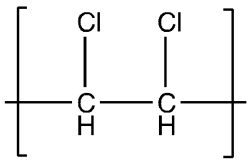

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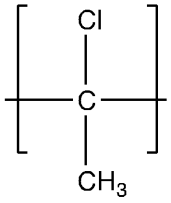


4. Which of the following treatments would successfully hydrolyse a sa
poly(ethylene terephthalate) (also called Terylene or PET)?

1: Soak in dilute sodium hydroxide
2: Boil in pure water
3: Soak in dilute hydrochloric acid

A 1 and 3 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

Topic 16: Organic Synthesis

1. Which of the following is the best way to synthesise phenylamine fro

A Heat benzene with ammonia at high temperature and pressure i the phenylamine.

B Nitrate benzene with a mixture of nitric and sulfuric acid; reflux hydrochloric acid.

C Reflux benzene with sodium cyanide in ethanol; react the produ nickel catalyst.

D Reflux benzene with ammonia dissolved in ethanol using the Fr $AlCl_3$; filter and recrystallise the phenylamine.

2. When methyl ethanoate is hydrolysed by refluxing with sodium hyd methanol and sodium ethanoate (an ionic salt). Which of the followi to purify the sodium ethanoate?

1: Distillation
2: Recrystallisation
3: Reduced pressure filtration

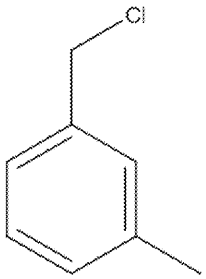
A 1 only

B 1 and 2

C 2 and 3

D 1, 2 and 3

3. Which of the reagents listed below would react with this molecule?



1: NaOH
2: Cl_2 with $AlCl_3$
3: A mixture of concentrated nitric and sulfuric acid

A 1 only

B 1 and 2

C 2 and 3

D 1, 2 and 3

4. Why is it important to measure the melting point of a solid product a

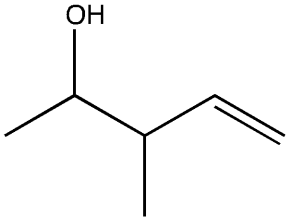
A To determine the identity and percentage yield of the product

B To determine the identity and purity of the product

C To determine the purity and percentage yield of the product

D To determine the identity, purity and percentage yield of the pro

5. By which mechanisms could the following molecule react? Choose a



1: Nucleophilic addition
2: Nucleophilic substitution
3: Electrophilic addition

A 1 only

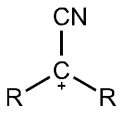
B 1 and 2

C 2 and 3

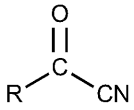
D 1, 2 and 3

6. Which of these represent what is produced in the first step of the rea HCN?

A



B



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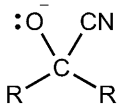

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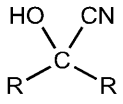


Topic 17: Analysis

1. Compound X reacts with 2,4-dinitrophenylhydrazine to give an oran
with Tollens' reagent to form a silver mirror. What functional group

A Aldehyde

B Ketone

C Primary alcohol

D Secondary alcohol

2. A student tests a white solid believed to be phenol by dissolving it in
concentrated solution and then adding universal indicator, which tu
this confirms the identity of the unknown compound as phenol. Wh
describes if the student is correct or not, and why?

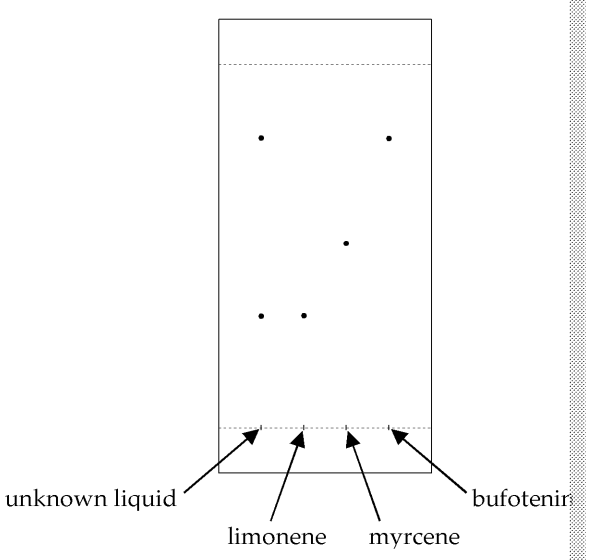
A The student is correct because phenol is acidic and acids turn un

B The student is not correct because phenol is only weakly acidic a
universal indicator red.

C The student is correct because phenol is both acidic and very sol

D The student is not correct because phenol is not the only water-s
acidic.

3. The diagram below shows a TLC chromatogram run on an unknow
substances – these are labelled on the diagram. What does this chro



A The unknown liquid is pure limonene.

B The unknown liquid is a mixture of limonene and bufotenin.

C The unknown liquid is a mixture of limonene and myrcene.

D The unknown liquid is not limonene, myrcene or bufotenin.

4. Which of the following statements correctly describes the high resolu
of 2-chloropropane?

   A Two triplets and a sextet

   B A triplet and a septet

   C A doublet and a septet

   D Two triplets and a doublet

5. Why is tetramethylsilane (TMS) solvent mixed with solutions before t
spectrometers?

   A Because it is a solvent that will not produce an NMR spectrum.

   B It provides the signal used as a reference for calculating chemica

   C It helps to identify when molecules have NH or OH groups.

   D It causes splitting patterns that are useful in analysing the spectr

Section B Answers

Topic 1: Orders, Rate Equations and Rate Constants

3. A
4. B

3. C
4. B

Topic 2: Rate Graphs and Orders

5. A
6. D
7. B
8. D

5. D
6. B
7. C

Topic 3: Effect of Temperature on Rate Constants

3. C
4. A

Topic 4: Equilibrium

5. A
6. D
7. A
8. B

5. B
6. C
7. D

Topic 5: Brønsted–Lowry Acids and Bases

7. B
8. C
9. A
10. C
11. D
12. A

7. C
8. A
9. B
10. C
11. B

Topic 6: Buffers and Indicators

4. C
5. A
6. B

4. A
5. D

Topic 7: Lattice Energies

3. D
4. B

3. D
4. A

Topic 8: Entropy and Free Energy

3. C
4. B

3. C
4. D

Topic 9: Redox and Electrode Potentials

4. A
5. B
6. D
4. C

5. A
6. D
7. A

Topic 10: Transitio

6. B
7. C
8. A
9. D
10. C

Topic 11: Qualitati

3. B
4. A

Topic 12: Aromatic
Substitution

5. C
6. A
7. B
8. D

Topic 13: Carbonyl

5. C
6. D
7. A
8. B

Topic 14: Nitrogen

4. A
5. B
6. D

Topic 15: Polyester

3. A
4. D

Topic 16: Organic S

4. B
5. C
6. D

Topic 17: Analysis

4. A
5. D
6. B