Zig Zag Education

Science

BTEC | BTEC National

2016 specification
first exams in 2017

Topic Tests

for BTEC National Applied Science

Principles and Applications of Science II

zigzageducation.co.uk

POD 8053

Contents

Teacher's Introduction

These topic tests have been designed to help you and your students assess their knowledge of a topic after you have taught each part of the Unit 5 modules of the **BTEC Applied Science** course. This part of the course corresponds to **Principles and Applications of Science II**.

Each topic test closely follows the content of the specification and includes:

- **Factual questions**: Some simpler factual questions are included to ensure that all the content and basics are covered, and to allow weaker learners access to some marks.
- **Short-answer questions**: These are not in exam style, and the purpose of these is to test different elements, knowledge and skills from the specification in a variety of styles.
- **Long-answer questions**: Where appropriate, topics may contain one or more extended response questions, to prepare students for what they might meet in the exam, and to test exam skills.

Mathematical skills are also covered in these topic tests.

Tests have been designed to take approximately 25–35 minutes to complete.

Students are able to see the number of marks awarded for each question, allowing them to gauge the level of detail they will require for the answers. Full answers with marks are included in the answers section. Additionally, it makes the resource a suitable tool for students to use independently.

Remember!

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

The topic tests are suitable for a classroom assessment, revision aid or homework task and are, therefore, suitable for use immediately after a topic is completed in class or at the end of teaching the course.

It is recommended that students have access to a calculator to complete the questions.

We hope you find these tests useful during your teaching.

November 2017

A1: Relating properties to uses and production of sub

1. Metal oxides are used as heat-resistant materials, catalysts and as raw metals.

a) Most metal oxides are considered basic.

Complete the balanced chemical equation to show how magnesium base when it reacts with hydrochloric acid, HCl.

$MgO + 2HCl \rightarrow$ ..... + ...

b) Magnesium can also form a base called magnesium hydroxide, $Mg(OH)_2$.

Which of these is a product when magnesium hydroxide reacts with

A	H_2O	
B	H_2	
C	O_2	
D	CO_2	

c) Al_2O_3, also known as alumina, is the raw material used to obtain

i) Alumina is amphoteric. What is the definition of the term 'amphoteric'?

A	Can absorb water from the air	
B	Is a solid at room temperature	
C	Can dissolve in water	
D	Can act as an acid or a base	

ii) Extraction of aluminium from alumina involves dissolving alumina and performing electrolysis.

Explain why this process is expensive.

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d) Identify **two** uses of copper and give two properties that make it s

Use 1: .....

Property 1: .....

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Use 2: .....

Property 2: .....

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2. Many metal compounds are vital in processes which shape modern li

a) Calcium hydroxide is used in waste water treatment. Explain ho this is important.

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b) Some transition metals and their co[illegible] are used as catalysts. For example, iron catalyse[illegible] in a process used to make oxide catalyses th[illegible] in the contact process.

i) [illegible] catalysts are important in these reactions.

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ii) State the final product of the contact process.

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iii) Suggest **two** rea[illegible] is more desirable to use iron as a platinu[illegible]

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2. .....

iv) Other than their catalytic ability, state **two** common properti

1. .....

2. .....

3. Bauxite is an aluminium ore.

a) Alumina can be extracted fro[illegible] using sodium hydroxide.

Describe how thi[illegible] works in terms of the chemicals presen

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b) Alumina can be used in refractories.

Identify **one** property of alumina which makes it suitable for use i

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c) Alumina can be processed further to make aluminium using the H

During this process, it is necessary to di[illegible] the alumina in mol

Explain why it is necessary to [illegible]lve alumina for this process to

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4. The extraction of titanium from its ore is a two-step process:
Reaction 1 uses chlorine and another element.
Reaction 2 uses magnesium.

a) In reaction 1, TiO_2 is converted to $TiCl_4$ by reacting it with chlorin added.

Name the other element used in reac[illegible] 1.

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b) W[illegible] a balanced symbol equation for reaction 2, where titanium magnesium.

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c) Titanium is used for hip replacements, planes and specialist spar

Identify **one** property that makes it more suitable than most othe

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d) The chlorine used in this pr[illegible] produced using the electrolys

Hydrogen gas [illegible] hydroxide are also produced in this p

i) [illegible]ntify the ions present in a solution of brine, including thos water.

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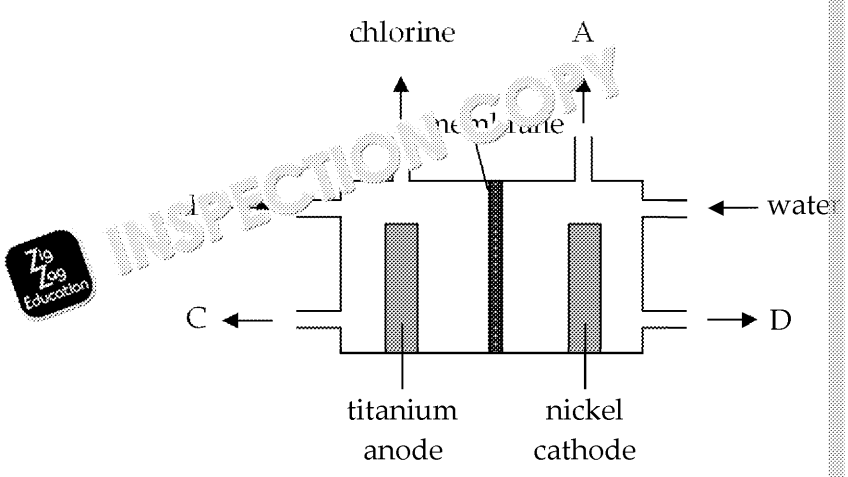
ii) The diagram below shows how brine can be used to create ch
membrane cell.

Identify suitable labels for the following diagram:



A: .....

B: .....

C: .....

D: .....

iii) Explain why it is advantageous to use a membrane cell for th
diaphragm cell.

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A2: Structures, reactions and properties of commerc organic compounds

1. Alkanes and alkenes are important chemicals obtained from crude oil

Alkanes can be used as fuels and lubricants, and alkenes are often use and other large molecules.

a) Many alkanes and alkenes h mers.

i) How mar are there of butane?

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ii) How many isomers of butane are straight-chain?

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b) Draw a cyclic alkene with 6 carbons.

c) Al and alkenes are homologous series which can be represe

Write the general formula of the alkanes.

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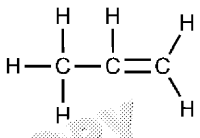
2. This diagram shows propene:



a) Identify the feature of this mole e which means that it is unsatu

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b) Write the shortened structural formula for this molecule.

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3. Methane, CH_4, is an alkane and a fuel.

a) Draw methane using a wedge/dash line diagram.

b) The bonding in methane can be explained using hybridisation.

i) Describe what is meant by the term *hybridisation*.

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ii) Explain how hybridisation occurs in methane.

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4. But-2-ene is an alkene used as a fuel and as a reagent for making com
compounds. But-2-ene contains a double bond.

a) Draw the skeletal formula of but-2-ene.

b) Explain whether b -en a symmetric or an asymmetric alker

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c) Describe the double bond in but-2-ene in terms of sigma- and pi-b

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5. Alkenes, alkanes and aromatic compounds like benzene have differen strengths.

Put the following in order:

a) Place benzene, cyclohexane, and the double bond in cyclohexene i

L

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Shortest: .....

b) Place benzene, cyclohexane, and the double bond in cyclohexene i

Strongest: .....

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Weakest: .....

6. Explain how the length of a straight-chain alkane affects its boiling po

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7. Ethane, C_2H_6, reacts with chlorine, Cl_2, in a radical substitution reactio three stages: initiation, propagation and termination.

a) State a key condition for the initiation stage.

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b) Write reactions which occur for the propagation stages and **one** t

Propagation

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Termination

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8. Alkenes are an important starting material for making many other kin
Alkenes commonly react with electrophiles.

a) Define the term 'electrophile'.

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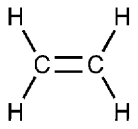
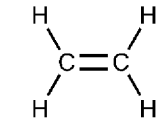
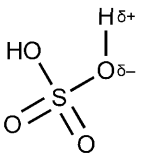
b) Draw the structure of the product of the addition reaction betwee
and water, H



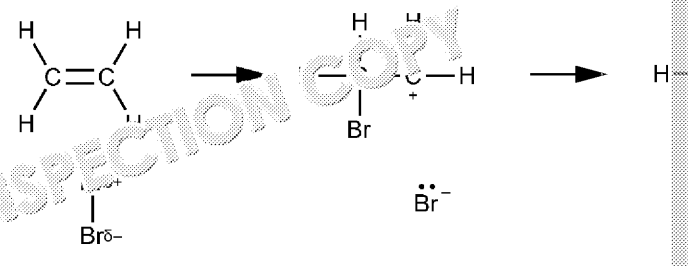
ethene

c) Add arrows to show the first step of the mechanism of the additio
to ethene.

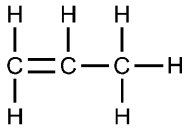




d) Complete the mechanism for the addition of bromine to ethane.



e) When propene reacts with hydrogen bromide, HBr, there are two



propene

Draw the displayed formulae of the products, and predict, with a reason, which of the products will be formed in the largest amount.

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9. Some reactions are particularly useful for creating valuable products.

a) Identify the type of product that organic peroxides are added to.

A	Alcohols	
B	Polymers	
C	Carboxylic acids	
D	Ketones	

b) Explain the purpose of cracking.

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A3: Energy changes in industry

1. Kelvin is a scale often used to measure temperature.

Write 310 K in °C.

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2. Enthalpy change has the symbol ΔH.

a) Which of these is the equation for the definition of enthalpy change?

A	ΔH = ΔV	
B	= ΔU – pΔV	
C	ΔH = ΔU × pΔV	
D	ΔH = ΔU ÷ pΔV	

b) Write the symbol for standard enthalpy change.

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c) What are the temperature and pressure for standard enthalpy change?

Temperature: .....

Pressure: .....

3. A reaction has an enthalpy change of -98 kJ mol^{-1}.

a) Explain why this is an exothermic or endothermic process.

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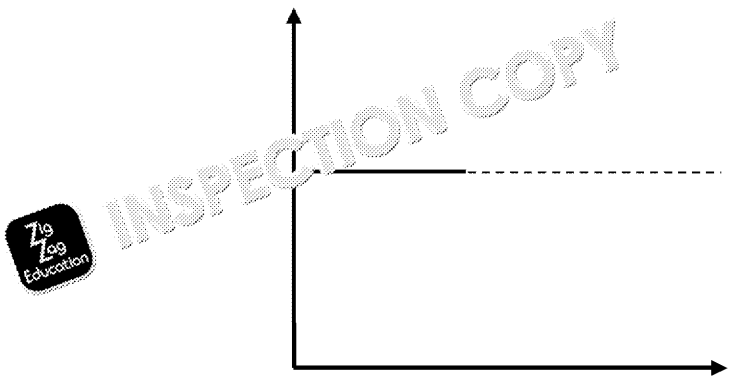
b) Complete a reaction profile for this reaction on the following axes.

- Labels for the axes
- A reaction curve
- Activation energy
- Energy change
- Reactants and products



4. Describe how the energy changes during an endothermic reaction in t
surroundings.

System .....

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Surroundings .....

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5. A stu ok up the literature values for the enthalpy changes of co

Alcohol	Enthalpy change ($kJ\ mol^{-1}$)
ethanol	-1367
propan-1-ol	-2021
butan-1-ol	-2676

a) Which of these alcohols will have the largest temperature change

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b) A student attempts to find th a of combustion of propan
equipment.

i) Plan an e experiment to find this value.
do not need to include details of calculations in your ans

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ii) Explain why the student obtains a value which is lower than

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iii) Suggest one way that the student can obt a value closer to

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6. Enthal fo ation is given the symbol ΔH_f

a) State the definition of enthalpy of formation.

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b) Predict the enthalpy of formation of C

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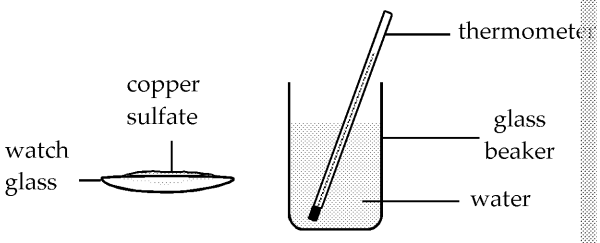
7. The en change of hydration of copper sulfate can be calculated fr the following apparatus:



a) 4.1 g of anhydrous copper sulfate, $CuSO_4$, was dissolved in 0.100

In this experiment, the temperature of the water increased by 6.0

Calculate the energy change for this proc s

Change in energy = mass × spec f h at capacity × change in temp

[The specific heat cap ty ater is 4.18 kJ kg^{-1} K^{-1}.]

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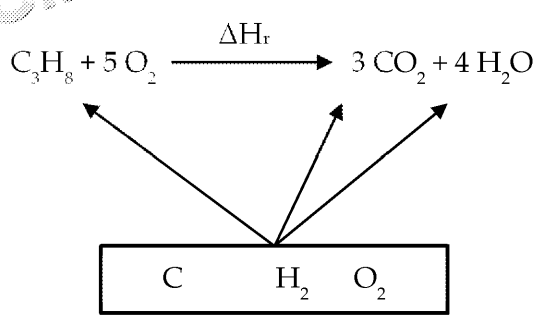
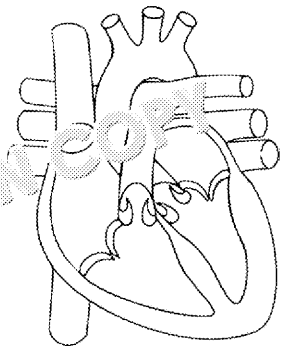
b) Use the values for the enthalpy of formation to calculate the enthalpy change, ΔH_r for the combustion reaction shown.

Compound	Standard enthalpy of formation
Propane, C_3H_8	-118.9
Carbon dioxide, CO_2	-393.5
Water, H_2O	-285.8



B1: The cardiovascular system

1. The figure below is an image of a mammalian heart.



a) On the figure, label:

i) The tricuspid valve (with an X)

ii) The bicuspid valve (with a Y)

b) Tick the heart structure that does **not** regulate heart conduction.

A	Sino-atrial node	
B	Atrioventricular node	
C	Bicuspid valve	
D	Purkinje fibres	

c) Describe how the electrical signal spreads across the heart.

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The heart is made of myogenic muscle.

d) How is myogenic muscle different to skeletal muscle?

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A patient has a resting heart rate of 112 beats per minute. The stroke v

e) What is the cardiac output of this patient? Give your answer in d

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f) Ic... which statement about the ABO rhesus system is **correct**

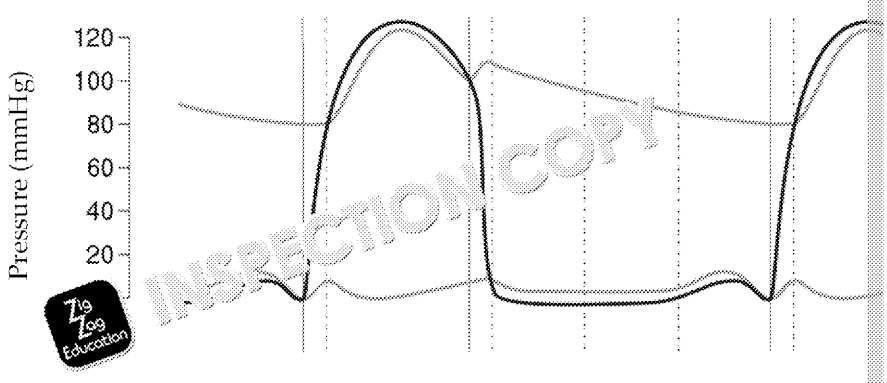
A	People with the AB blood group produce anti-A and anti-B a
B	Universal donors normally have the blood group AB.
C	A reaction to anti-D antibody indicates the blood is Rh-.
D	O blood group samples do not have ABO group antigens on the

2. Connect these vessels with their key characteristics.

Largest lumen	
Highly elasticated	
...f diffusion	
High blood pressure	
One cell thick	
Contains valves	

3. The figure below shows the pressure changes associated with the card

a) Label, with the letters indicated:



i) The **diastole** phase of the cardiac cycle (D)
ii) The point at which the bicuspid valve closes (E)
iii) The point at which the semilunar valve opens (F)

b) Describe how blood pressure changes in blood vessels between th

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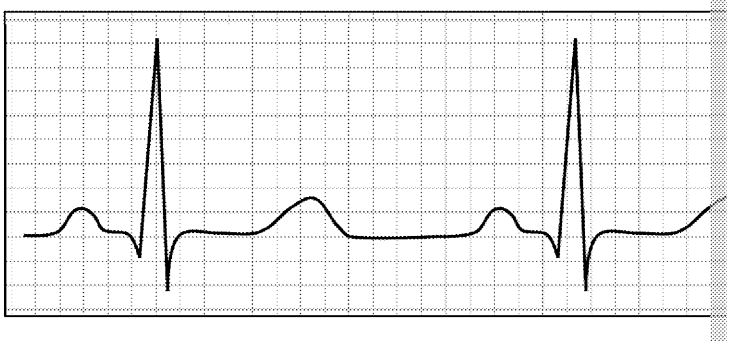
4. Electr g ms (ECGs) can be used to identify changes in the hea the ele conduction that regulates heart rhythm.



A normal ECG trace is shown above.

a) What heart condition would be repres y n ECG trace show rapid peaks?

A	Bradyc	
	cardia	
	Arrhythmia	
D	Ectopic heartbeat	

b) **i)** On the trace, circle the QRS complex.

ii) Explain the significance of this complex.

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5. Cardiovascular di[illegible] (CVD) is the single most significant killer of th[illegible]

a) W[illegible]k factors put people at risk of cardiovascular diseases, an[illegible] ab[illegible] the disease?

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b) List two possible disadvantages of the use of antihypertensive me[illegible]

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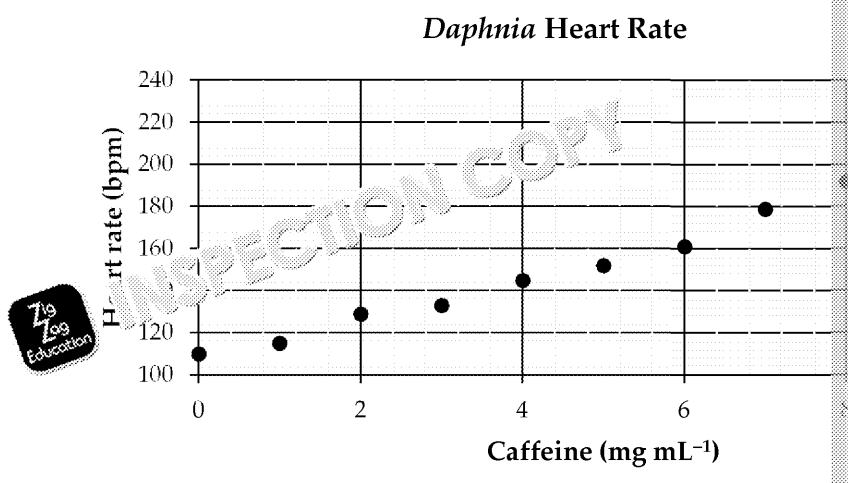
6. A student is investigating the effect of caffeine on the heart rate of the
The results are shown below.



a) How much caffeine is dissolved in 35 mL of water to make a 6 mg

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b) Explain how caffeine affects *Daphnia* heart rate, suggesting why t
reach a plateau.

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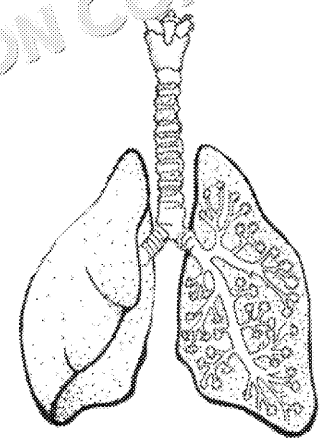
B2: Ventilation and gas exchange

1. Label the diagram below of the human gas exchange system with the

- Alveolus
- Trachea
- Bronchus
- Bronchiole



2. The lungs are surrounded by a thin, membranous sack called the pleu

What are the functions of the pleural membranes?

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3. Several stages in a single breath cycle are shown below.

a) State the role of each statement.

i) The intercostal muscles relax.

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ii) The diaphragm contracts.

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iii) Pressure in the thorax is increased.

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Certain conditions, such as chronic obstructive pulmonary disease (C
the lungs.

b) How can medics ensure a patient with COPD can access enough o

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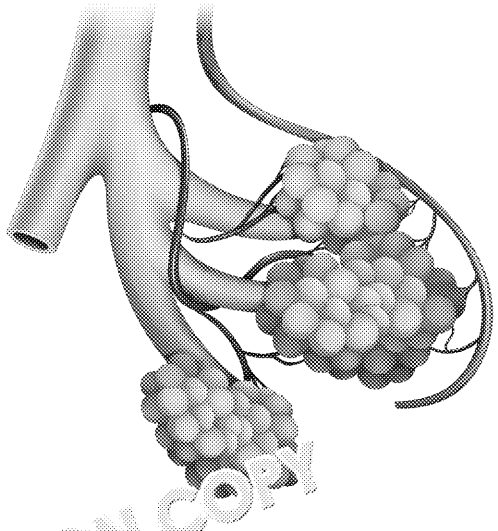
4. The diagram below sh a d awing of some alveoli.



a) List three adaptations f l eoli that ensure efficient exchange

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The efficiency of the lungs can be estimated using an assembly of med

b) What name is given to this apparatus?

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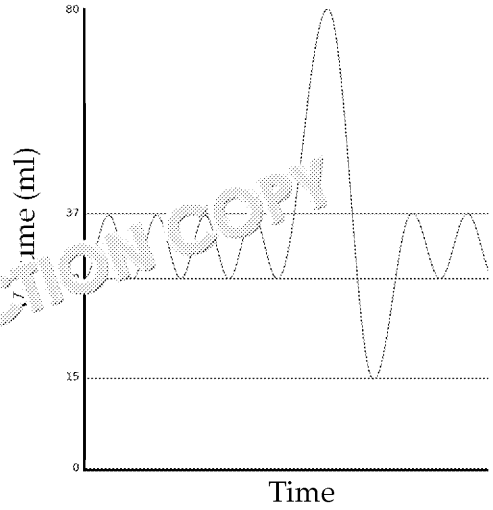
A trace from this apparatus is shown below.



The data below shows the volumes obtained from the trace above. O
1.5 seconds

Reading	Volume (mL)
Tidal Volume	560
Inspiratory Reserve Volume	3400
Residual Volume	1200
Expirat[illegible] Volume	1200
Vital Capacity	
Total Lung Capacity	

c) Using the data provided in the table, calculate the vital capacity a

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d) Calculate the volume of air inhaled during nor[illegible]al breathing ove

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The respiratory condition asthma can be diagnosed using a modified v
the page above.

Peak expiratory flow is one method of diagnosing asthma.

e) What can be determined from peak expiratory flow measurement

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f) How do t[illegible]asures differ from forced vital capacity measure

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5. Following a period of increased exercise, there are profound differenc
breathes.

a) Describe the aspects of a spirometer trace after an individual und

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b) Using your answers to the questions above, indicate how tidal vo
consumption are related.

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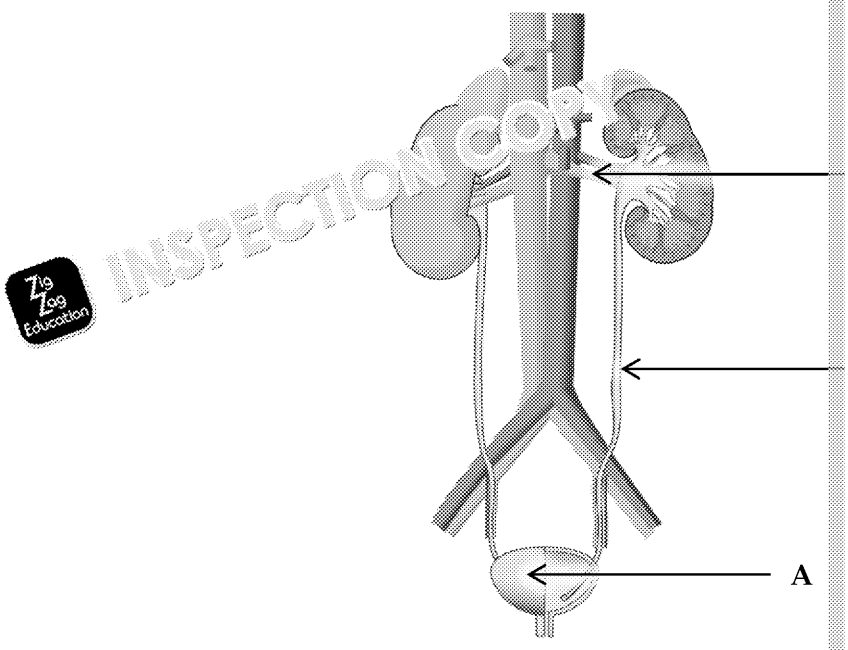
B3: Urinary system structure and function

1. The urinary system is shown below.



a) What are the functions of this system?

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b) Give the name and the function of the:

i) Organ labelled A

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ii) Tube labelled B

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iii) Vein labelled C

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2. The function of the kidney depends on the nephron – the microscopic

a) How are the glomerulus and Bowman's capsule related?

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b) A[illegible]h part of the nephron is glucose reabsorbed? Why is this

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c) What part of the nephron regulates the concentration of urine?

A	Glomerulus	
B	Bowman's capsule	
C	Proximal convoluted tubule	
D	Loop of Henle	

d) O[illegible]h[illegible]lood osmolarity is detected and controlled by the b

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The body is able to regulate blood pressure through differential contr

e) Complete the gaps in this description of the renin-angiotensin-ald

The renin-angiotensin-aldosterone (RAA) mechanism can control blo

concentration of ..... in the blood

When blood flow is reduced, or when ..... concentra

to ..... the kidney.

This ... nogen into a shorter protein, called .....

ar... to ..... causing the blood pressure to .....

Reabsorption of ..... ions is also controlled by this sy

..... ions into the urine in their place.

3. Following kidney failure, patients are often faced with one of two opt transplantation.

a) Why is renal dysfunction so harmful to a patient?

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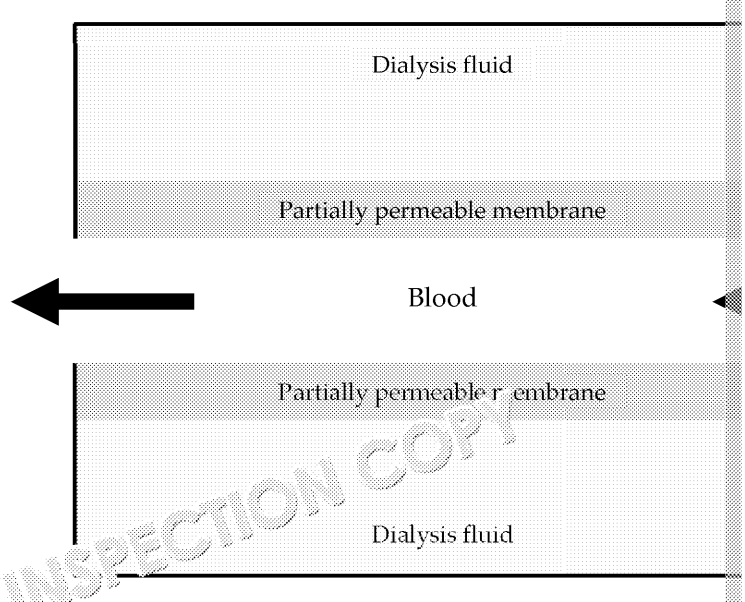
The di... below outlines the mechanism of renal dialysis used.



b) On ... diagram,

i) Use dotted lines to show the direction of dialysis fluid flow.

ii) Use solid black lines to show the direction of urea movement

c) Explain why dialysis fluid must contain the same concentration o

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d) Dialysis is us[illegible] greater numbers of patients than transplant

E[illegible] why many more patients will be treated with dialysis rat

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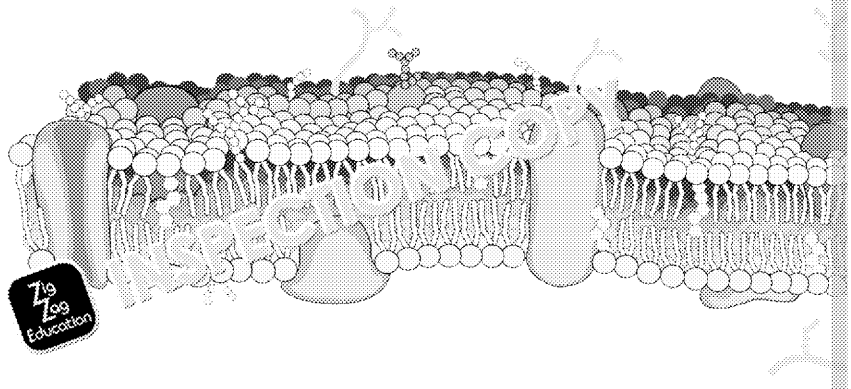
B4: Cell transport mechanisms

1. The cell surface membrane is shown below.



a) What role do phospholipids play in the cell surface membrane?

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b) The cell surface membrane is dotted with cholesterol throughout.

i) Under what circumstances is the amount of cholesterol in the

A	Increased pressure	
B	Increased temperature	
C	Increased number of proteins	
D	Increased size of cell	

ii) Explain the importance of your answer to question 1.b)i).

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A student argues that the cell surface membrane is like a rigid wall, d movement of substances across the wall.

c) To what extent would you agree with the student?

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d) What is the difference between intrinsic and extrinsic membrane p

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e) Explain why lipid-soluble molecules, such as caffeine, can have ra
while lipid-insoluble molecules take much longer to have an effec

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2. Cells are able to acquire their required substances through a number o

a) How does facilitated diffusion differ from passive diffusion?

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b) State two factors which determine whether a substance crosses a m
by diffusion.

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c) Name the method for the passive transport of water across a mem

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d) Using your example from (c), explain why this method is consider
transport.

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3. Active transport is used in order to move glucose from the small intes

a) Why do cells of the intestinal lumen contain a high density of mit

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The process of phagocytosis is an example of endocytosis. This is a fo

b) Describe how an immune cell will take up a bacterium by endocyt

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Cells that produce hormones often secrete the hormone into a vesicle.

c) Explain the necessity to encapsulate the hormones in a vesicle in o the cell.

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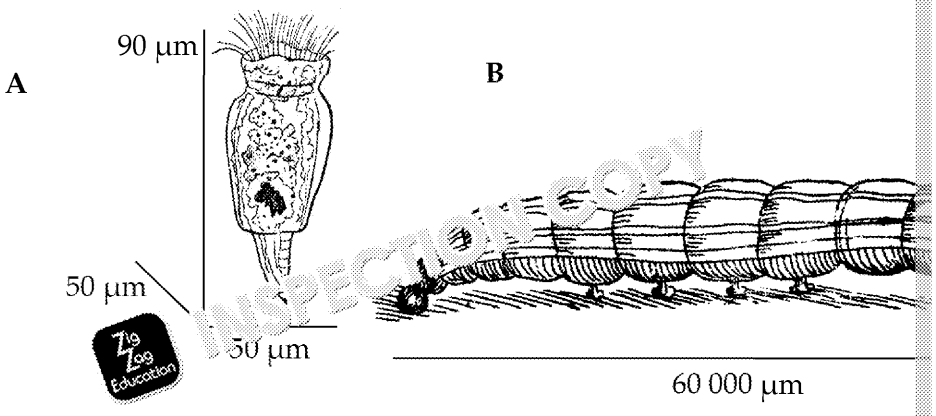
4. An illustration of two organisms is shown below.



a) Calculate the surface area to volume ratio of organism A.

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b) The surface area to volume ratio of organism B is 1:1200

i) What does your answer to a) indicate about the effect of organism size on diffusion molecules?

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ii) Suggest how the larger organism may be adapted to transport

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C1: Thermal physics in domestic and industrial applica

1. a) Convert the following quantities into different units:

i) 6500 W to kW

.....

ii) 3.2 MW to W

.....

ii GW to kW

.....

b) Select an equivalent unit for Pascal (Pa).

A	N m	
B	$N\ m^{-1}$	
C	$N\ m^{-2}$	
D	$N^2\ m^{-1}$	

2. a) Select the definition of the work done on an object.

A	The energy transferred to the ob	
B	The force applied to the o	
C	The dista object moves	
	e energy dissipated from the object	

b) A crate is pushed 2.4 m along the ground with a resultant force o

Using an equation from the formulae sheet, calculate the work do

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c) The box is compressed from a volume of 1 to 1.40 m^3, with cons

Using an equation fro formulae sheet, calculate the pressure

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3. A motor converts 75 J into 42 J of kinetic energy.

   a) What has happened to the rest of the energy?

   .....

   .....

   b) Using an equation from the formulae sheet, calculate the efficiency

   .....

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4. a) A heat engine has a heat input of 660 J and a heat output of 59 J.

   Using an equation from the formulae sheet, calculate the efficiency

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   b) The heat sink of the engine has a temperature of 550 K and the source of 340 K.

   Using an equation from the formulae sheet, calculate the maximum efficiency of the heat engine.

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5. A light bulb converts 500 J of electrical energy to 470 J of light energy, with the output being heat energy.

   a) State the law of conservation of energy.

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b) Calculate the amount of heat energy given out by the light bulb.

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c) Using an equation from the formulae sheet, calculate the efficiency

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6. A volume of 0.77 m^3 of an ideal gas contains 9.82×10^{23} molecules. The

Using an equation from the formulae sheet, calculate the pressure of t

Use $k = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}.

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7. **a)** Select an example of an isothermal process.

A	Compression of a gas	
B	Free expansion of an ideal gas	
C	A gas increasing in temperature	
D	A change of state	

b) Select an example of an adiabatic process.

A	Free expansion of an ideal gas	
B	Friction causing a rise in temperature	
C	A change of state	
D	A gas being compressed by a motor	

8. a) State the first law of thermodynamics.

.....

.....

b) Heat is inputted into a gas. The internal energy of the gas increas
of work.

Using an equation from the formulae sheet, calculate the heat inp

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9. a) Fill in the gaps usin[illegible] below to described idealised engi

a change	**no change**	**equal to**
positive	**negative**	**zero**

An idealised engine cycle is one in which there is .....

volume at the start of the engine cycle will be .....

end of the engine cycle. The work done and change in internal energ

..... .

b) State the second law of thermodynamics.

.....

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c) W[illegible] an idealised engine cycle never be achieved in practice?

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10. a) i) Describe how a heat engine works.

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ii) Give an application of a heat engine.

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b) Describe how a refrigerator works.

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c) State the general name of a device which moves heat energy from

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d) What is meant by the maximum theoretical coefficient of perform
refrigerator, or heat pump?

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11. a) Describe how the kinetic ene d intermolecular forces in a sy
melting.

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b) Two objects at the same temperature are said to be in thermal equ

What is meant by this statement?

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.....

12. a) What is meant by the term 'th[illegible] capacity'?

.....

.....

b) 1.30 kg of water is heated from 10.0 °C to 86.0 °C.

The specific heat capacity of water is 4.18 kJ kg^{-1} K^{-1}.

Using an equation from the formulae sheet, calculate the energy u

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c) Why is water useful as a coolant i[illegible]?

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d) The latent heat of fusion for cobalt is 243 kJ kg^{-1}.

Using an equation from the formulae sheet, calculate the mass of c melted by 615 kJ of heat at constant temperature and pressure.

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e) Why is cobalt a useful mater[illegible] high temperature processes?

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C2: Materials in domestic and industrial applications

1. **a)** What is meant by 'elasticity'?

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b) Suggest an application for a material with high elasticity.

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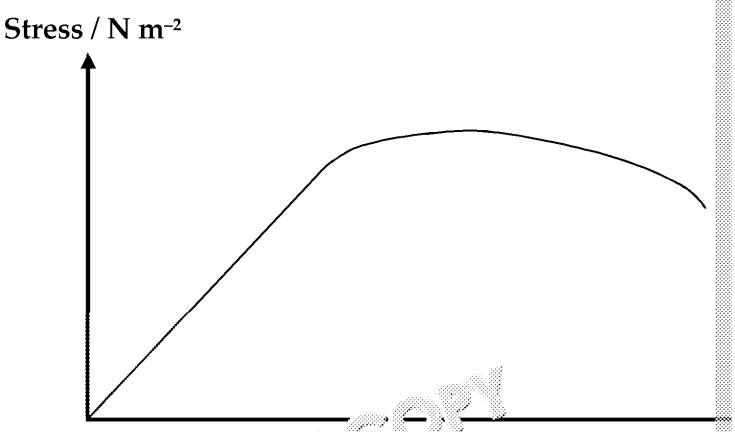
2. A stress-strain curve for a material is shown below.



a) What do stress-strain curves show?

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b) Mark the elastic limit and yield point of the material on the stress

c) What is meant by the strength of a material?

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d) Explain which part of the stress-strain graph shows elastic deform
shows plastic de

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3. **a)** Describe how creep and fatigue differ.

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b) Select an appl[illegible] a highly ductile material.

A	[illegible]porting a hanging platform	
B	Drawing the material into a wire	
C	Moulding the material into a statue	
D	As a supportive framework for a tall building	

c) Explain why highly brittle materials are not suitable for building s

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d) Give an appli[illegible] a malleable material.

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e) Explain why a rubber band heats up as it is stretched, and what th of this is.

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f) State the name of the process described in 3.e).

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4. Match up the following quantities with their symbols and units.

Quantity
Density
Tensile/compressive stress
Tensile/compressive strain
Young modulus

Symbol
ε
E
ρ
σ

5. A block of plastic has a density of 1.44 kg m^{-3} and a mass of 0.550 kg.

Using an equation from the formulae sheet, calculate the volume of the

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6. A wire with a spring constant of 5.95×10^3 N m^{-1} is stretched with a force to a length of 28.0 cm.

a) Using an equation from the formulae sheet, calculate the extension

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b) The stress on the wire while it is being stressed is 32.2 MN m^{-2}.

Using an equation from the formulae sheet, calculate the cross-sectional

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c) Using an equation from the formulae sheet and your answer from part **a)**, calculate the energy stored in the wire when it is stretched.

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7. The Young modulus of a material describes how it responds to stress a

a) Using equations from the formulae sheet, write down a formula f
wire in terms of the dimensions of the wire and the force applied

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b) A ... has a Young modulus of 210 MN m^{-2}. The wire is stretche
th... stretches from 30.0 cm to 34.5 cm.

Using your answer to a), calculate the cross-sectional area of the w

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8. **a)** A wire is stretched by 8.40 cm and stores an elastic energy of 2.25

Calculate the force stretching the wire.

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b) Using equations from the formulae sheet, write down an equation
energy in a wire in terms of the extension of a wire and the spring

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c) A wire has a spring constant of 710 N m^{-1} a... compressed so th
potential energy.

Using your equation fro... rt ..., calculate the compression of the

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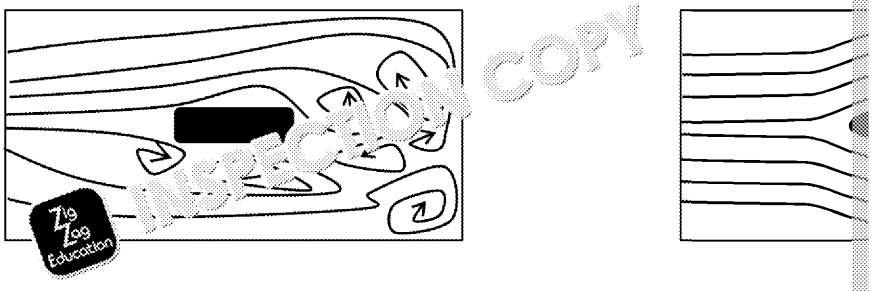
C3: Fluids in motion

1. Below are shown two fluid flow patterns around objects in identical p

Flow A



a) State the type of flow observed in each diagram. Explain your an

Flow A: .....

.....

Flow B: .....

.....

b) Which flow object will experience a greater force if moving throu
Explain your answer.

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c) State two factors that affect whether a flow is streamlined or turb

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d) Select an example of a situation in w'ich t[illegible]ulent flow is prefera

A	When transp[illegible]g f[illegible]om one place to another
B	[illegible]he [illegible]ying paint
C	[illegible]hen stirring is needed
D	The flow of air around a racing car

e) What can be said about the mass of fluid flow per second in the p

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2. Two identical obj[illegible]opped through two cylinders containing t

One o[illegible]uids, fluid A, is significantly more viscous than the other

a) Explain which object will reach the bottom of the fluid quicker.

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b) The fluid is heated up.

Explain how this w[illegible]l affe[illegible]t the speed at which the object falls thr

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c) Explain how the motion of the object would be different if it were into a non-Newtonian fluid, like cornflour mi[illegible]re.

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3. **a)** State Bernoulli's principle.

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b) Gas is flowing uniformly through a sealed [illegible]. More gas is added

Explain how this affects the [illegible] of the gas.

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c) A plane's wing has a larger surface area on top of the wing than b[illegible]

Explain how the shape of a plane's wing allows it to fly through t[illegible]

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A1: Relating properties to uses and production of sub

1. Metal oxides are used as heat-resistant materials, catalysts and as raw ma

a) Most metal oxides are considered basic.

Copy and complete the balanced chemical equation to show how acts as a base when it reacts with hydrochloric acid, HCl.

$MgO + 2HCl \rightarrow$ [?] + [?]

b) Magnesium oxide will form a base called magnesium hydroxide, M

Which of these is a product when magnesium hydroxide reacts w

A	H_2O
B	H_2
C	O_2
D	CO_2

c) Al_2O_3, also known as alumina, is the raw material used to obtain a

i) Alumina is amphoteric. What is the definition of the term 'am

A	Can absorb water from the air
B	Is a solid at room temperature
C	Can dissolve in water
D	Can act as a reactant and a base

ii) Extraction of aluminium from alumina involves dissolving al forming electrolysis.

Explain why this process is expensive.

d) Identify **two** uses of copper and give two properties that make it s

2. Many metal compounds are vital in processes which shape modern li

a) Calcium hydroxide is used in waste water treatment. Explain ho this is important.

b) Some transition metals and their compounds are used as catalysts. For example, iron catalyses the reaction in a process used to make oxide catalyses the reaction in the contact process.

i) State why catalysts are important in these reactions.

ii) State the final product of the contact process.

iii) Suggest two reasons why it is more desirable to use iron as a inum.

iv) Other than their catalytic ability, state **two** common properties

3. Bauxite is an aluminium ore.

   a) Alumina can be extracted from bauxite using sodium hydroxide. Describe how this process works in terms of the chemicals present

   b) Alumina can be used in refractories.

   Identify **one** property of alumina which makes it suitable for use

   c) Alumina can be processed further to make aluminium using the H

   During this process it is necessary to dissolve the alumina in mol

   E[illegible] why it is necessary to dissolve alumina for this process to

4. The extraction of titanium from its ore is a two-step process:
   Reaction 1 uses chlorine and another element.
   Reaction 2 uses magnesium.

   a) In reaction 1, TiO_2 is converted to $TiCl_4$ by reacting it with chlorin added.

   Name the other element used in reaction 1.

   b) Write a balanced symbol equation for reaction 2, where titanium chlo

   c) Titanium is used for hip replacements, planes and specialist spark

   Identify **one** property that makes it more suitable than most othe

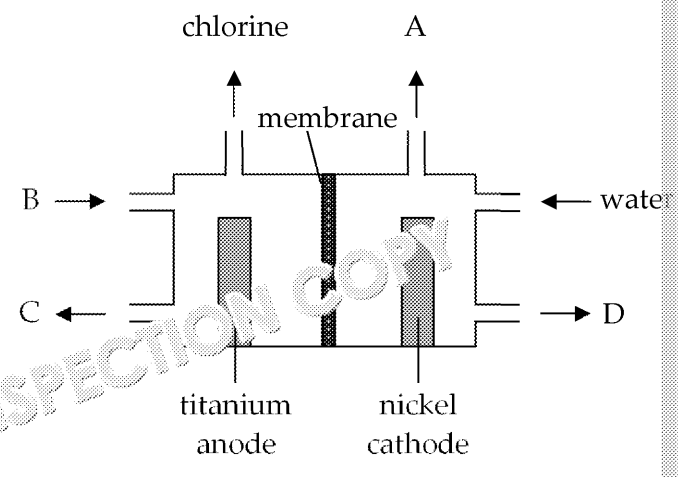
   d) The chlorine used in this process is produced using the electrolys

   Hydrogen gas and sodium hydroxide are also produced in this p

   i) Identify the ions present in a solution of brine, including thos water.

   ii) The diagram below shows how brine can be used to create ch membrane cell.

   Identify suitable labels for A, B, C and D in the following dia



   iii) Explain why it is advantageous to use a membrane cell for th diaphragm cell.

A2: Structures, reactions and properties of commerc organic compounds

1. Alkanes and alkenes are important chemicals obtained from crude oil

Alkanes can be used as fuels and lubricants, and a nes are often use and other large molecules.

a) Many alkanes and a e have isomers.

i) How many isomers are there of butane?

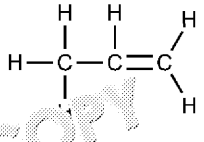
ii) How many isomers of butane are straight-chain?

b) Draw a cyclic alkene with 6 carbons.

c) Alkanes and alkenes are homologous series which can be represe

Write the general formula of the alkanes.

2. This diagram shows propene:



a) Identify the feature of th ole ule which means that it is unsatu

b) Wri he ed structural formula for this molecule.

3. Metha CH_4, is an alkane and a fuel.

a) Draw methane using a wedge/dash line diagram.

b) The bonding in methane can be explained using hybridisation.

i) Describe what is meant by the term *hybridisation*.

ii) Explain how hybridisation occurs in methane.

4. But-2-ene is an alkene used as a fuel and as a reagent for making com compounds. But-2-ene contains a double bond.

a) Draw the skeletal formula of bu e.

b) Explain whether but-2-ene is a symmetric or an asymmetric alker

c) D e the double bond in but-2-ene in terms of sigma- and pi-b

5. Alkenes, alkanes and aromatic compounds like benzene have differen strengths.

   Put the following in order:

   a) Place benzene, cyclohexane, and the double bond in cyclohexene i

   b) Place benzene, cyclohexane, and the double bond in cyclohexene i

6. Explain how the length of a strai[illegible]ain alkane affects its boiling po

7. Ethane, C_2H_6, rea[illegible]orine, Cl_2, in a radical substitution reactio three s[illegible]: i[illegible]n, propagation and termination.

   a) St[illegible]ey condition for the initiation stage.

   b) Write reactions which occur for **two** propagation stages and **one** t

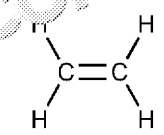
   Propagation

   Termination

8. Alkenes are an important starting material for making many other kin Alkenes commonly react with electrophiles.

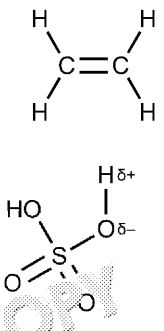
   a) Define the term 'electrophile'.

   b) Draw the structure of the product of the additi[illegible]n reaction betwee and water, H_2O.

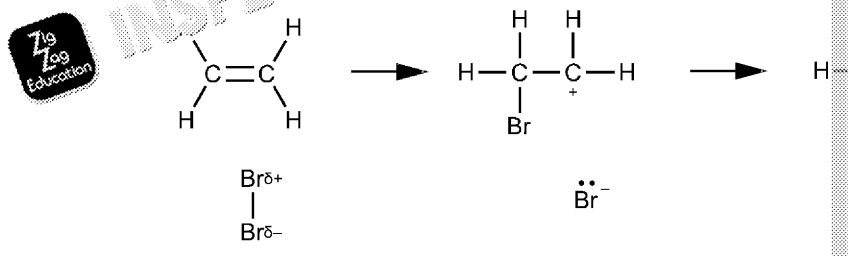


ethene

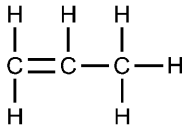
   c) Copy the diagrams below and add arrows to show the first step o addition of sulfuric acid, H_2SO_4 to ethene.



   d) Copy the diagrams belo[illegible]nplete the mechanism for the ad



e) When propene reacts with hydrogen bromide, HBr, there are two



propene

Draw the displayed formulae of the products, and predict, with a reason, which of the products will be formed in the largest amount.

9. Some reactions are particularly useful for creating valuable products.

a) Identify the type of product when organic peroxides are added to

A	Alcohols
B	Polymers
C	Carboxylic acids
D	Ketones

b) Explain the purpose of cracking.

A3: Energy changes in industry

1. Kelvin is a scale often used to measure temperature.

   Write 310 K in °C.

2. Enthalpy change has the symbol ΔH.

   a) Which of these is the equation for the definition of enthalpy chan

A	$\Delta H = \Delta U + p\Delta V$
B	ΔH [illegible]
C	$= \Delta U \times p\Delta V$
D	$\Delta H = \Delta U \div p\Delta V$

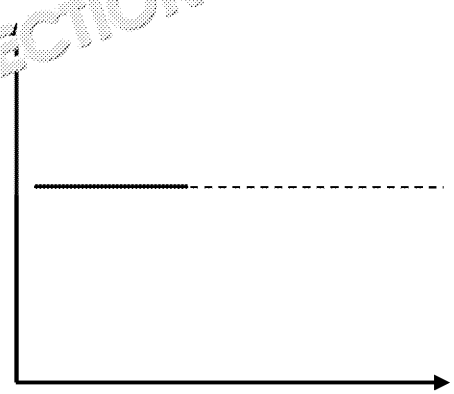
   b) Write the symbol for standard enthalpy change.

   c) What are the temperature and pressure for standard enthalpy cha

3. A reaction has an enthalpy change of -98 kJ mol^{-1}.

   a) Explain whether this is an exothermic or endothermic process.

   b) Copy the axes below and complete a reaction profile for this react
   - Labels for the axes
   - A reaction curve
   - Activation energy
   - Energy change
   - Reactants and products



4. Describe how the energy changes during an endothermic reaction in t surroundings.

5. A student looks up the literature values for the enthalpy changes of co

[illegible]	Enthalpy change (kJ mol^{-1})
ethanol	-1367
propan-1-ol	-2021
butan-1-ol	-2676

   a) Which of these alcohols will have the largest temperature change

b) A student attempts to find the enthalpy of combustion of propan
equipment.

i) Plan a suitable experiment to find this value.

You do not need to include details of calculations in your ans

ii) Explain why the student obtains a valu[illegible]ich is lower than

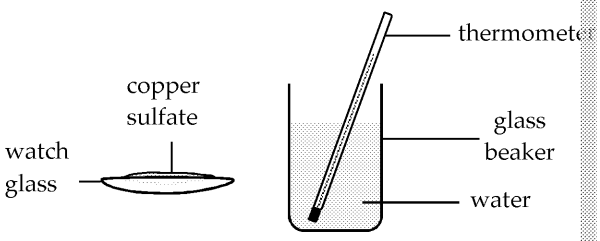
iii) Suggest one way that the st[illegible]n obtain a value closer to

6. Enthalpy of forma[illegible]n the symbol ΔH_f

a) S[illegible]e definition of enthalpy of formation.

b) Predict the enthalpy of formation of $O_{2(g)}$.

7. The energy change of hydration of copper sulfate can be calculated fr
the following apparatus:



a) 4.1 g of anhydrous copper sulfate, $CuSO_4$, was dissolved in 0.100 k

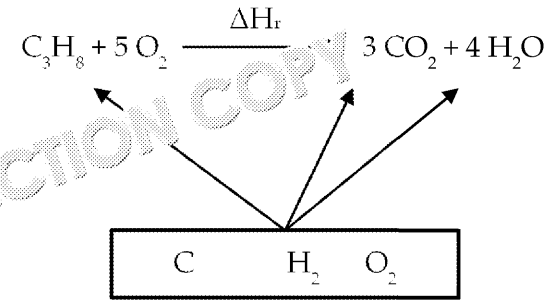
In this experiment, the temperature of th[illegible]e increased by 6.0

Calculate the energy change [illegible]s process.

Change in ener[illegible] = specific heat capacity × change in temp
[Th[illegible]ec[illegible]t capacity of water is 4.18 kJ kg^{-1} K^{-1}.]

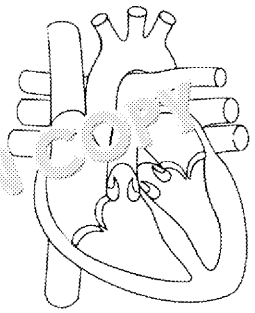
b) Us[illegible]e values for the enthalpy of formation to calculate the entha
ΔH_r for the combustion reaction shown.

Compound	Standard enthalpy of formati
Propane, C_3H_8	-118.9
Carbon dioxide, CO_2	-393.5
Water, H_2O	-285.8



B1: The cardiovascular system

1. The figure below is an image of a mammalian heart.



a) Sketch the figure above and label:

i) The tricuspid valve (with an X)

ii) The bicuspid valve (with a Y)

b) Choose the heart structure that does **not** regulate heart conductio

A	Sino-atrial node
B	Atrioventricular node
C	Bicuspid valve
D	Purkinje fibres

c) Describe how the electrical signal spr[illegible] os[illegible] the heart.

The heart is made of myog[illegible]e.

d) How is m[illegible] muscle different to skeletal muscle?

A patie[illegible]as a resting heart rate of 112 beats per minute. The stroke

e) What is the cardiac output of this patient? Give your answer in d

f) Identify which statement about the ABO rhesus system is **correct**

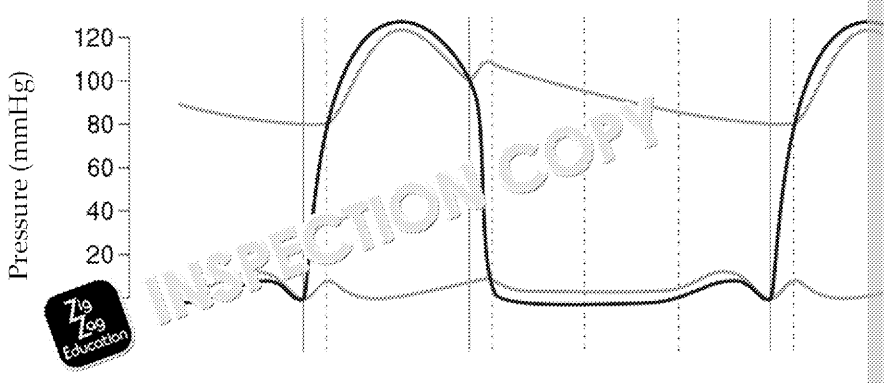
A	People with the AB blood group produce anti-A and anti-B
B	Universal donors normally have the blood group AB.
C	A reaction to anti-D antibody indicates the blood is Rh-.
D	O blood group samples do not have ABO group antigens on the

2. Copy the table below and connect these v[illegible]ls [illegible]th their key charact

Largest lumen	
Elastic[illegible]s	
[illegible]f diffusion	
High blood pressure	
One cell thick	
Contains valves	

3. The figure below shows the pressure changes associated with the card

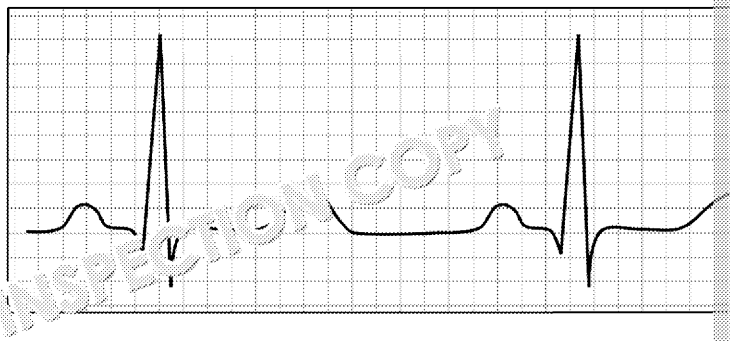
a) Copy the graph below and label, with the letters indicated:



i) The **diastole** phase of the cardiac cycle (D)
ii) The point at which the bicuspid valve closes (E)
iii) The point at which the semilunar valve opens (F)

b) Describe how blood pressure changes in blood vessels between th

4. Electrocardiograms (ECGs) can be used to identify changes in the hea the electrical conduction that regulates heart rhythm.



A norm G trace is shown above.

a) What heart condition would be represented by an ECG trace show rapid peaks?

A	Bradycardia
B	Tachycardia
C	Arrhythmia
D	Ectopic heartbeat

b) **i)** Sketch the trace and circle the QRS comple

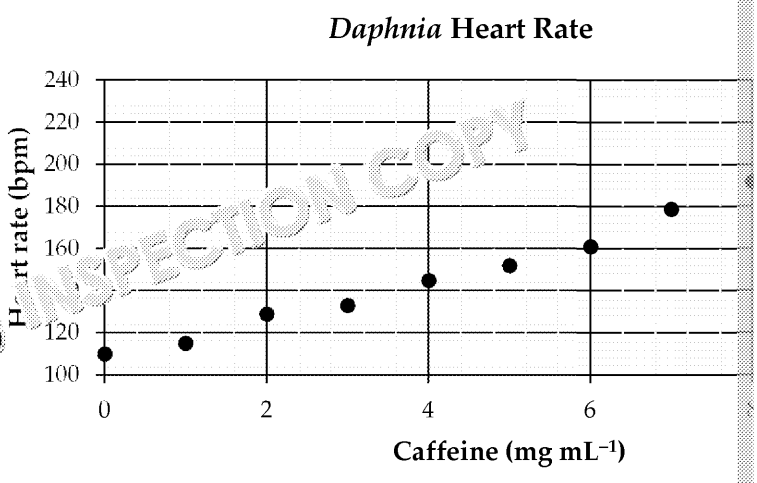
ii) Explain the significance of

5. Cardiovascular di) is the single most significant killer of th

a) W k factors put people at risk of cardiovascular diseases, an ab e disease?

b) List two possible disadvantages of the use of antihypertensive m

6. A student is investigating the effect of caffeine on the heart rate of the
The results are shown below.

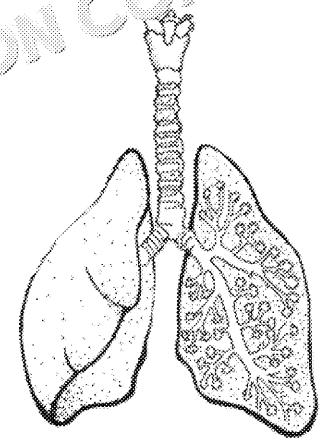


a) How much caffeine is dissolved in 35 mL of water to make a 6 mg

b) Explain how caffeine affects *Daphnia* heart rate, suggesting why t
reach a plateau.

B2: Ventilation and gas exchange

1. Sketch and label the diagram below of the human gas exchange syste
- Alveolus
- Trachea
- Bronchus
- Bronchiole



2. The lungs are surrounded by a thin, membranous sack called the pleu

What are the functions of the pleural membranes?

3. Several stages in a single breath cycle are shown b l w.

a) State the role of each statement.

i) The intercostal m sc s r lax.

ii) d phragm contracts.

iii) Pressure within the thorax is increased.

Certain conditions, such as chronic obstructive pulmonary disease (C
the lungs.

b) How can medics ensure a patient with COPD can access enough

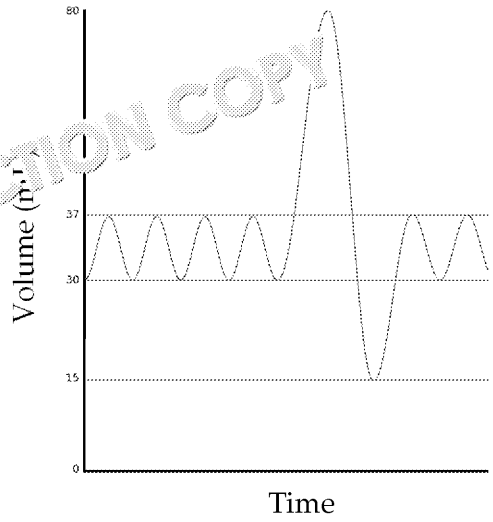
4. The diagram below shows a drawing of some alveoli.

a) List three adaptations of the alveoli that ensure efficient exchange

The efficiency of the lungs can be estimated using an assembly of med

b) What name is given to this apparatus?

A trace from this apparatus is shown below.



The data below shows the volumes obtained from the trace above. O
1.5 seconds

Reading	Volume (mL)
Tidal Volume	560
Inspiratory Res[illegible]ume	3400
Resi[illegible]ume	1200
[illegible]ratory Reserve Volume	1200
Vital Capacity	
Total Lung Capacity	

c) Using the data provided in the table, calculate the vital capacity a

d) Calculate the volume of air inhaled during normal breathing ove

The respiratory condition asthma can be diagnosed using a modified
the page above.

Peak expiratory flow is one method of diagnosing asthma.

e) What can be determined from peak expiratory flow measuremen

f) How do these measures differ from f[illegible]al capacity measure

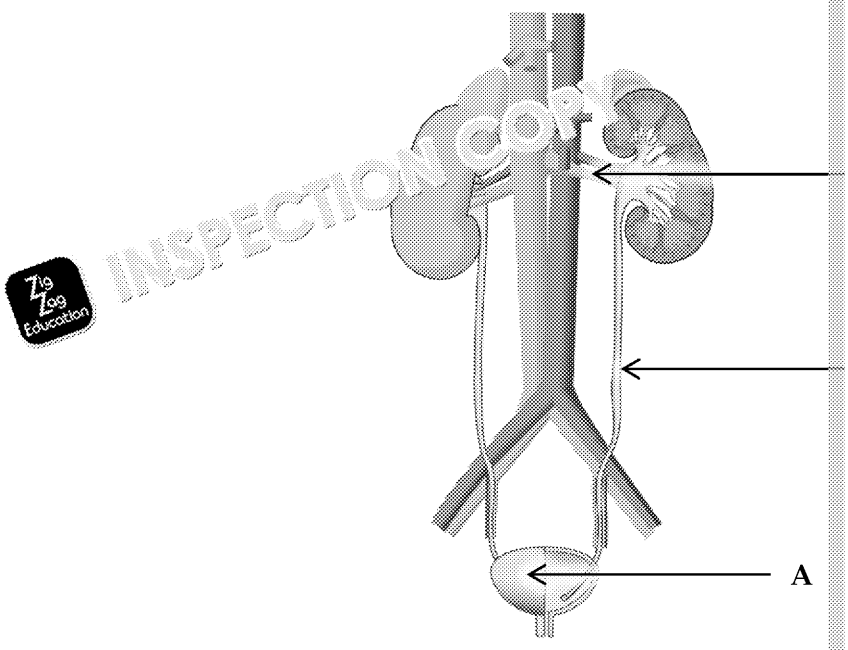
5. Following a period of inc[illegible]ercise, there are profound differenc
breaths.

a) D[illegible] the aspects of a spirometer trace after an individual und

b) Using your answers to the questions above, indicate how tidal vo
consumption are related.

B3: Urinary system structure and function

1. The urinary system is shown below.



a) What are the functions of this system?

b) Give the name and the function of the:

i) Organ labelled A

ii) Tube labelled B

iii) Vein labelled C

2. The function of the kidney depends on the nephron – the microscopic

a) How are the glomerulus and Bowman's capsule related?

b) At which part of the nephron is glucose reabsorbed? Why is this

c) What part of the nephron regulates the concentration of urine?

A	Glomerulus
B	Bowman's capsule
C	Proximal convoluted tubule
D	Loop of Henle

d) Outline how blood osmolarity is detected and controlled by the b

The body is able to regulate blood pressure through differential contr

e) List the words needed to complete this description of the renin-a mechanism and complete the gaps.

The renin-angiotensin-aldosterone (RAA) mechanism can control blo

concentration of ..... in th... a

When blood flow is reduced ... . concentra

to .... g cells in the kidney.

T... angiotensinogen into a shorter protein, called .....

arterioles to ..... causing the blood pressure to .....

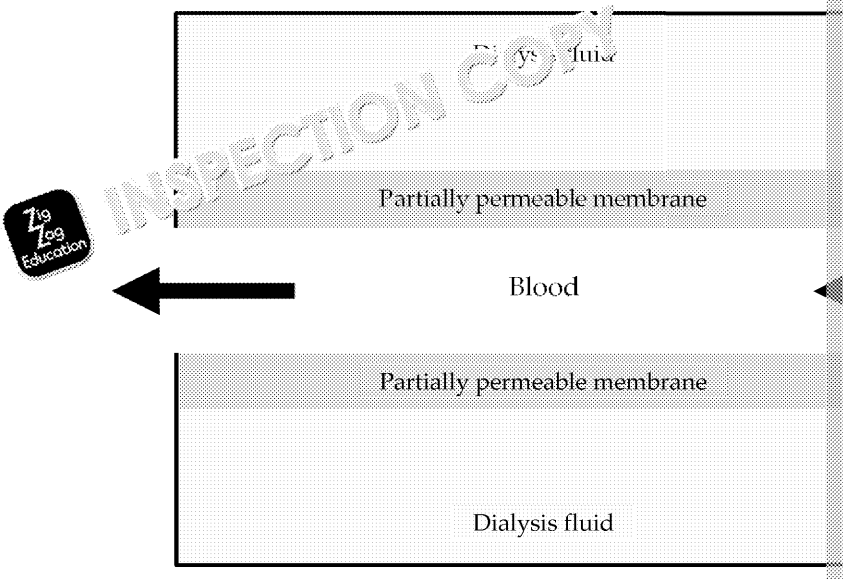
Reabsorption of ..... ions is also controlled by this sy

..... ions into the urine in their place.

3. Following kidney failure, patients are often faced with one of two opt transplantation.

a) Why is renal dysfunction so harmful to a patient?

The diagram below outlines the mechanism of renal dialysis used.



b) Sketch the diagram and add the following:

i) Dotted lines to show the direction of ... fluid flow.

ii) Solid black lines to sho... ...rection of urea movement.

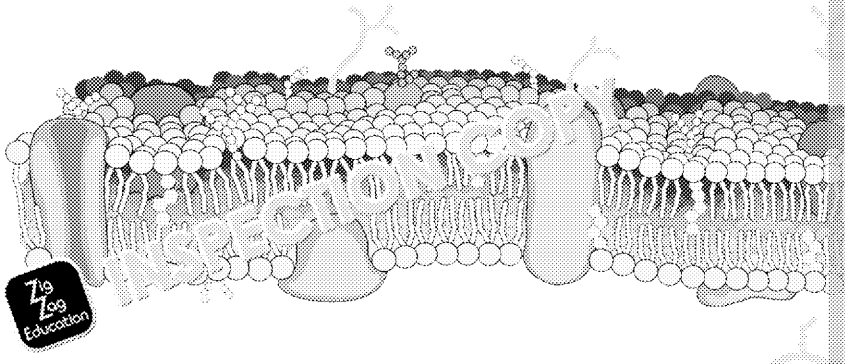
c) Explain wh... ...fluid must contain the same concentration o

d) Di... is used in far greater numbers of patients than transplan

Explain why many more patients will be treated with dialysis rat

B4: Cell transport mechanisms

1. The cell surface membrane is shown below.



a) What role do phospholipids play in the cell surface membrane?

b) The cell surface membrane is dotted with cholesterol throughout.

i) Under what circumstances is the amount of cholesterol in the

A	Increased pressure
B	Increased temperature
C	Increased number of proteins
D	Increased size of [illegible]

ii) [illegible] importance of your answer to question 1.b) i).

A student argues that the cell surface membrane is like a rigid wall, d
movement of substances across the wall.

c) To what extent would you agree with the student?

d) What is the difference between intrinsic and extrinsic membrane p

e) Explain why lipid-soluble molecules, such as caffeine, can have ra
while lipid-insoluble molecules take much longer to have an effec

2. Cells are able to acquire their required substances th[illegible]ough a number o

a) How does facilitated diffusion differ [illegible]ssive diffusion?

b) State two factors wh[illegible] determine whether a substance crosses a
passive diffu[illegible]

c) N[illegible]e method for the passive transport of water across a men

d) Using your example from c), explain why this method is consider
transport.

3. Active transport is used in order to move glucose from the small intes

a) Why do cells of the intestinal lumen contain a high density of mit

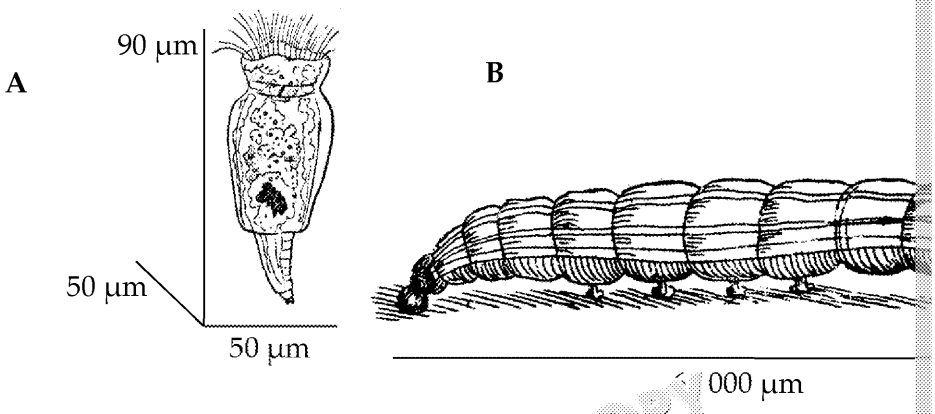
The process of phagocytosis is an example of endocytosis. This is a fo

b) Describe how an immune cell will take up a ba erium by endocy

Cells that produce hormones ofte e hormone into a vesicle.

c) Explain the nece capsulate the hormones in a vesicle in
the

4. An illustration of two organisms is shown below.



a) Calculate the surface area to e ratio of organism A.

b) The surfac olume ratio of organism B is 1:1200

i) t does your answer to a) indicate about the effect of orga
of molecules?

ii) Suggest how the larger organism may be adapted to transpo

C1: Thermal physics in domestic and industrial applica

1. **a)** Convert the following quantities into different units:

i) 6500 W to kW

ii) 3.2 MW to W

iii) 14 GW to kW

b) Select an equi[illegible] for Pascal (Pa).

A	[illegible]n
B	N m^{-1}
C	N m^{-2}
D	N^2 m^{-1}

2. **a)** Select the definition of the work done on an object.

A	The energy transferred to the object.
B	The force applied to the object.
C	The distance the object moves.
D	The energy dissipated from the object.

b) A crate is pushed 2.4 m alon[illegible] round with a resultant force o

Using an equati[illegible] he formulae sheet, calculate the work do

c) Ti[illegible] is compressed from a volume 3.60 m^3 to 1.40 m^3, with cons

Using an equation from the formulae sheet, calculate the pressur

3. A motor converts 75 J into 42 J of kinetic energy.

a) What has happened to the rest of the energy?

b) Using an equation from the formulae sheet, calculate the efficienc

4. **a)** A heat engine has a heat input of 660 J and a heat output of 59 J.

Using an equation from the formulae sheet, calcu[illegible] the efficienc

b) The heat sink of a heat engine has a [illegible]mperature of 550 K and the
of 340 K.

Using an e[illegible]m the formulae sheet, calculate the maximu
th[illegible] engine.

5. A light bulb converts 500 J of electrical energy to 470 J of light energy,
output being heat energy.

a) State the law of conservation of energy.

b) Calculate the amount of heat energy given out by the light bulb.

c) Using an equation from the formulae sheet, calculate the efficienc

6. A volume of 0.77 m^3 of an ideal gas contains 9.82×10^{23} molecules. The t

Using an equation from the formulae sheet, calc[illegible] the pressure of th

Use $k = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}

7. **a)** Select an exa[illegible] isothermal process.

A	mpression of a gas
B	Free expansion of an ideal gas
C	A gas increasing in temperature
D	A change of state

b) Select an example of an adiabatic process.

A	Free expansion of an ideal gas
B	Friction causing a rise in temperature
C	A change of state
D	A gas being compressed b[illegible] m[illegible]r

8. **a)** State the fi[illegible] of thermodynamics.

b) He[illegible] nputted into a gas. The internal energy of the gas increas[illegible] of work.

Using an equation from the formulae sheet, calculate the heat inp[illegible]

9. **a)** Copy the following paragraph and fill in the gaps using the word[illegible] idealised engine cycles.

a change	**no change**	**equal to**
positive	**negative**	**zero**

An idealised engine cycle is one in whic[illegible] .....

volume at the start of th[illegible] cycle will be ..... *t*

end of the [illegible]ycle. The work done and change in internal energ

..... .

b) State the second law of thermodynamics.

c) Why can an idealised engine cycle never be achieved in practice?

10. a) i) Describe how a heat engine works.

ii) Give an application of a heat engine.

b) Describe how a refrigerator works.

c) State the general name of a device which moves heat energy from

d) What is meant by the [illegible] theoretical coefficient of performa refrigerator, or a heat pump?

11. a) Describe how the kinetic energy and intermolecular forces in a sy melting.

b) Two objects at the same temperature are said to be in thermal equi

What is meant by this statement?

12. a) What is meant by the term 'thermal capacity'?

b) 1.30 kg of water is heated from 10.0 °C to 86.0 °C.

The specific heat capacity of water is 4.18 kJ kg^{-1} K^{-1}.

Using an equation from the formulae sheet, calculate the energy u

c) Why is water useful as a coolant in industry?

d) The latent heat of fusion for cobalt is 243 kJ kg^{-1}.

Using an equation from the formulae sheet, calculate the mass of melted by 615 kJ of heat at constant temperature and pressure.

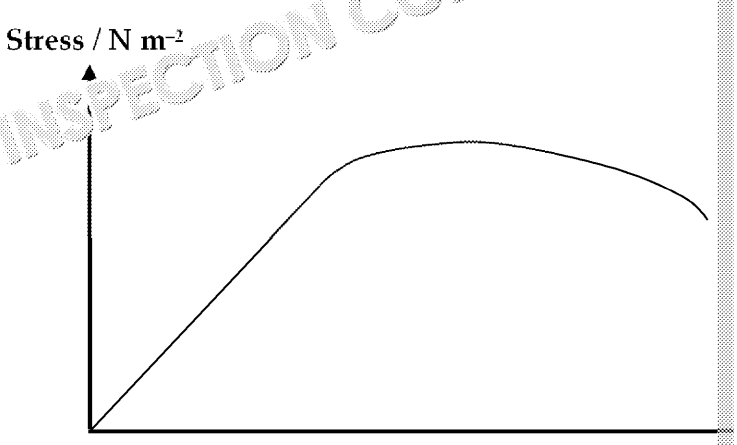
e) Why is cobalt a useful material for high temperature processes?

C2: Materials in domestic and industrial applications

1. **a)** What is meant by 'elasticity'?

b) Suggest an application for a material with high elasticity.

2. A stress-strain curve for a material is shown below.



a) What do stress-strain curves show?

b) Copy the graph and mark the elastic limit and yield point of the material on the curve.

c) What is meant by the strength of a material?

d) Explain which part of the stress-strain graph shows elastic deformation and which shows plastic deformation.

3. **a)** Describe how creep and fatigue differ.

b) Select an application of a highly ductile material.

A	Supporting a hanging platform
B	Drawing the material into a wire
C	Moulding the material into a statue
D	As a supportive framework for a tall building

c) Explain why highly brittle materials are unsuitable for building structures.

d) Give an application of a malleable material.

e) Explain why a rubber band heats up as it is stretched, and what this is called.

f) State the name of the process described in 3.e).

4. Match up the following quantities with their symbols and units.

Quantity
Density
Tensile/compressive stress
Tensile/compressive strain
Young modulus

Symbol
ε
E
ρ
σ

5. A block of plastic has a density of 1.44 kg m^{-3} and a mass of 0.550 kg.

Using an equation from the formulae sheet, calculate the volume of the

6. A wire with a spring constant of 5.95×10^3 N m^{-1} is stretched with a force length of 28.0 cm.

a) Using an equation from the formulae sheet, calculate the extension

b) The stress on the wire while it is being stressed is 32.2 MN m^{-2}.

Using an equation from the formulae sheet, calculate the cross-sec

c) Using an equation from the formulae sheet and your answer from the wire when it is stretched.

7. The Young modulus of a material describes how it responds to stress a

a) Using equations from the formulae sheet, write down a formula for wire in terms of the dimensions of the wire and the force applied

b) A wire has a Young modulus of 210 MN m^{-2}. The wire is stretched the wire stretches from 30.0 cm to 34.5 cm.

Using your answer to a), calculate the cross-sectional area of the w

8. **a)** A wire is stretched by 8.40 cm and stores an elastic energy of 2.25

Calculate the force stretching the wire.

b) Using equations from the formulae sheet, write down an equation energy in a wire in terms of the extension of a wire and the spring

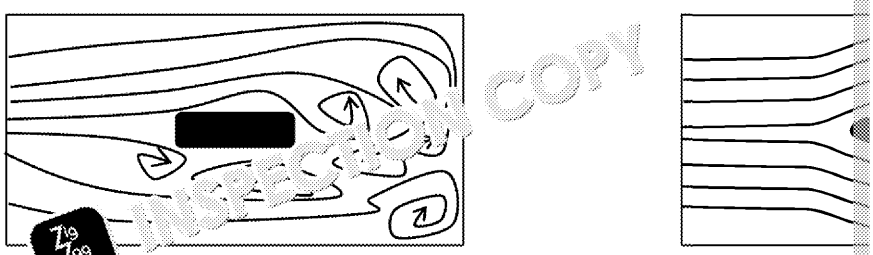
c) A wire has a spring constant of 710 N m^{-1}. It is compressed so th potential energy.

Using your equation from part b), calculate the compression of the

C3: Fluids in motion

1. Below are shown two fluid flow patterns around objects in identical p

Flow A



a) State the type of flow observed in each diagram. Explain your an

b) Which flow object will experience a greater force if moving throu
Explain your answer.

c) State two factors that affect whether a flow is streamlined or turb

d) Select an example of a situation in which turbulent flow is prefera

A	When transporting fuel from one place to another
B	When spraying paint
C	When stirring is needed
D	The flow of air around [illegible] car

e) Wh[illegible] about the mass of fluid flow per second in the p

2. Two id[illegible]ical objects are dropped through two cylinders containing t

One of the fluids, fluid A, is significantly more viscous than the other

a) Explain which object will reach the bottom of the fluid quicker.

b) The fluid is heated up.

Explain how this will affect the speed at which the object falls thr

c) Explain how the motion of the object would be different if it were
into a non-Newtonian fluid, like cornflour mixture.

3. **a)** State Bernoulli's principle.

b) Gas is flowing [illegible] through a sealed pipe. More gas is add

E[illegible] h[illegible] this affects the rate of flow of the gas.

c) A plane's wing has a larger surface area on top of the wing than b

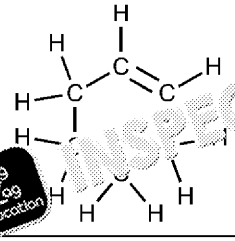
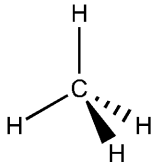
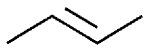
Explain how the shape of a plane's wing allows it to fly through t

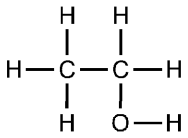
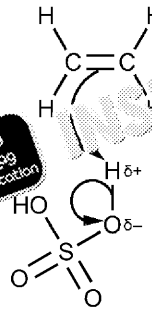
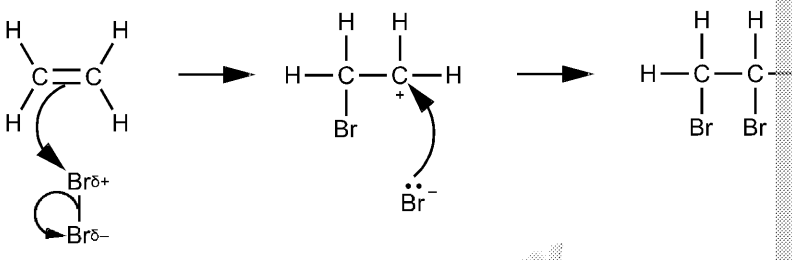
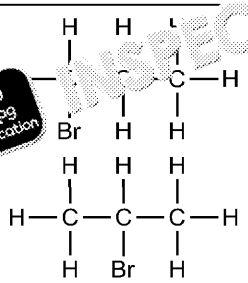
Answers

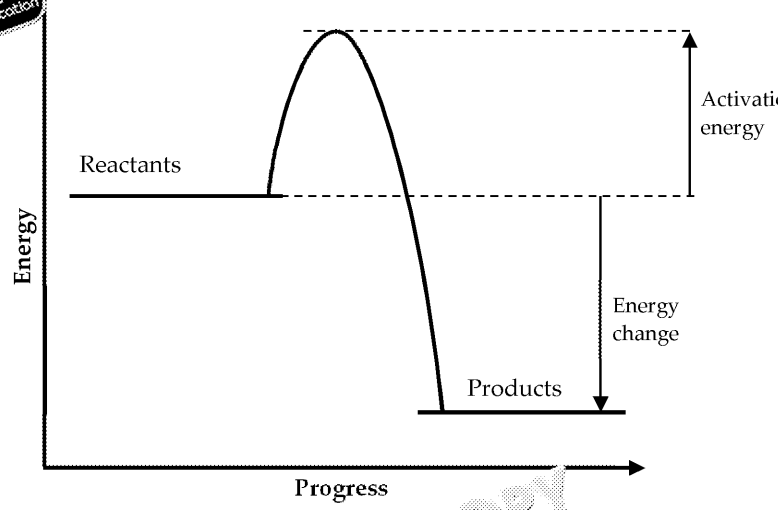
A1: Relating properties to uses and production of substances

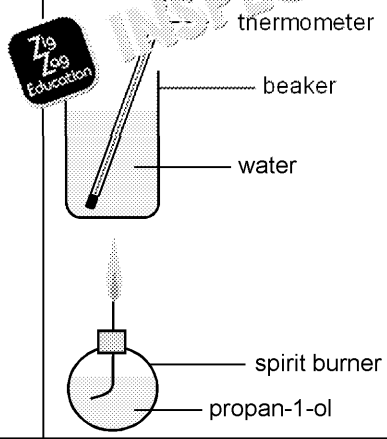
Question	Answer
1a	$MgCl_2$ H_2O
1b	**A** H_2O
1ci	**D** Can act as [illegible] a base
1cii	[illegible]rge [illegible]s of electricity used to generate heat [illegible]h temperatures needed to melt cryolite [illegible]uel is expensive
1d	*Any 2 uses,* *Any relevant properties:* **In wires** Electrically conductive **In pans (etc.)** Thermally conductive **Coins** Low reactivity **Building (e.g. roofs)** Unreactive/strong
2a	*Any two:* • Neutralises acidic effluent • To avoid corrosion of me[illegible]pi[illegible]s • Acids are harm[illegible]e[illegible]vironment • Acids ar[illegible]h[illegible]hamans / shouldn't be drunk
2bi	[illegible]y • Increase the rate • More product in a given time • Lower temperature can be used
2bii	Sulfuric acid
2biii	• Iron may work better • Iron is less expensive
2biv	*Any two:* • Variable oxidation state • Form complexes • Form coloured compounds
3a	*Any six from:* • Bauxite contains a mixture of oxides • Alumina is soluble in sodium h[illegible]ox[illegible] • Other oxides are not so[illegible]in [illegible]ium hydroxide • (alumina is / o[illegible] are not) amphoteric • Impu[illegible] [illegible] is crystallised • Dried/dehydrated at 1000 °C • To remove water of crystallisation
3b	High melting point OR Thermal insulator
3c	To form a mixture with a lower melting point

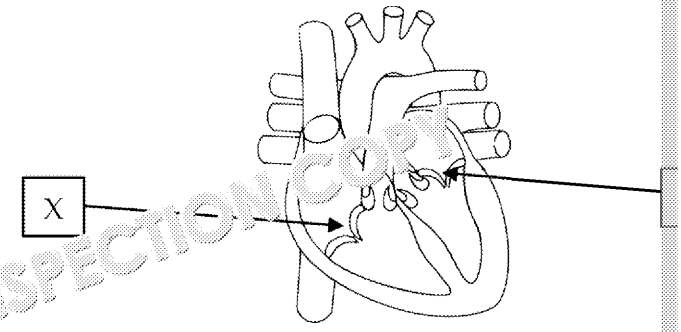
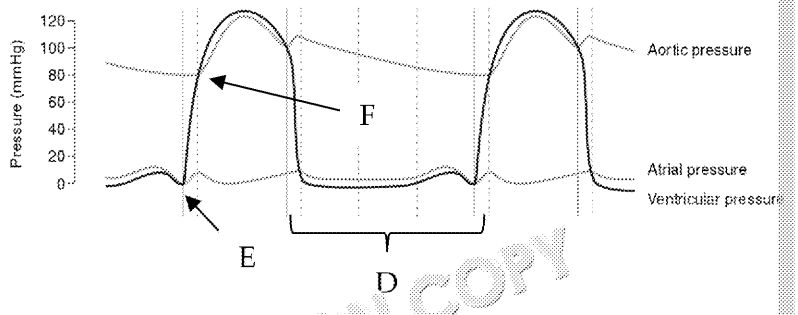
Question	Answer
4a	Carbon
4b	$TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$
4c	*Any one:* • Low density • Unreactive
4di	Cl^-, Na^+ H^+, OH^-
4dii	**A** – hydrog – (s ted) salt solution / water, d ute/used salt water / solution – sodium hydroxide
4diii	Diaphragm cell produces impure/contaminated sodium hydroxid OWA

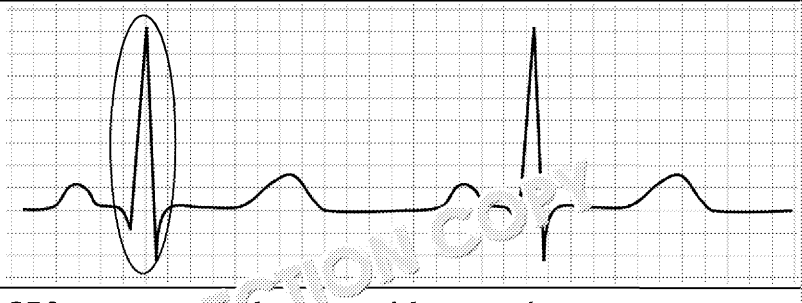
Question	Answer
1ai	Two
1aii	One
1b	Six-carbon ring with correct number of hydrogen atoms double bond 
1c	C_nH_{2n+2}
2a	Double bond
2b	CH_3CHCH_2
3a	 CH_4 Correct wedge, dash and lines
3bi	Orbitals mix/combine to form new 'hybrid' orbitals.
3bii	The s and the three p orbitals on carbon hybridise to form four sp^3 orbitals.
4a	
4b	Symmetrical the carbons on either side of the double bond have the same substituents/groups.
4c	Made up of a sigma and a pi bond
5a	Order of length is: Longest: cyclohexane benzene Shortest: double bond in cyclohexene
5b	Order of strength is: Strongest: double bond in cyclohexene benzene Weakest: cyclohexane
6	• Longer chains give higher boiling point • More electrons • Stronger van der Waals forces
7a	UV light / bright sunlight
7b	*Propagation* • $C_2H_6 + Cl^\bullet \rightarrow C_2H_5^\bullet + HCl$ • $C_2H_5^\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl^\bullet$ *Termination (any one)* • $C_2H_5^\bullet + Cl^\bullet \rightarrow C_2H_5Cl$ $C_2H_5^\bullet + C_2H_5^\bullet \rightarrow C_4H_{10}$ • $Cl^\bullet + Cl^\bullet \rightarrow Cl_2$
8a	Lone pair acceptor

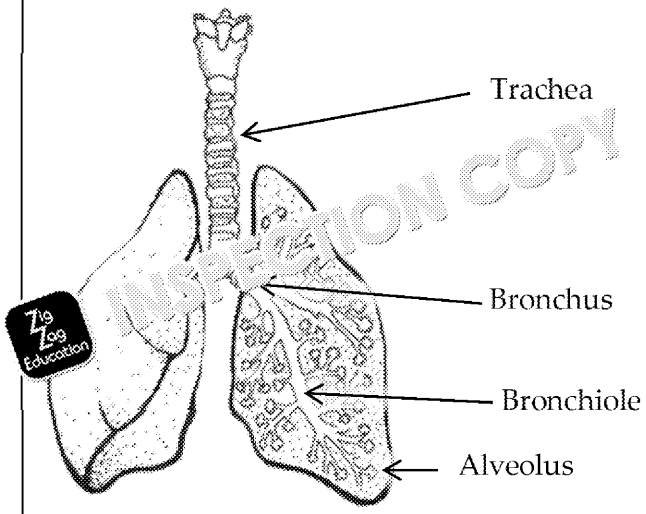
Question	Answer
8b	 Correct atoms Correctly bonded
8c	 Arrow from C=C to H Curly arrow from O–H to O
8d	 Arrow from C=C to Br Correct dipole on Br–Br Correct carbocation with [illegible] correct arrow from Br⁻ to positive
8e	 The second of these Formed from the more stable/secondary cation
9a	**B** Polymers
9b	Converts long-chain alkanes in crude oil into short-chain alkanes which are more useful / in high demand.

Question	Answer
1	310 – 273 = 37 °C
2a	**A** $\Delta H = \Delta U + p\Delta V$
2b	$\Delta H^{\ominus}$
2c	298 K 1×10^5 Pa OR 100 kPa
3a	Exothermic because the value is negative
3b	 • Labels for the axes • Curve goes higher than reactant and product lines and ends at • Activation energy shown • Energy change shown • Products lower than reactants
4	System: increases Surroundings: decreases
5a	Butan-1-ol

Question	Answer
5bi	*One each:* • Burn propan-1-ol in a spirit burner • Under a beaker of water • Water known mass/volume • Measure temperature change in the water • Using a thermometer • Weigh mass of spirit burner before and after *Award relevant marks from a labelled diagram, i.e.* 
5bii	Because heat will be lost / temperature change won't be as high
5biii	*Any one:* • Insulate the flask/container/beaker • Move the flame closer to the water
6a	The enthalpy change when one mole of a substance is formed in its standard state at 298 K and 100 kPa from its elements in their standard state
6b	
7a	Change in energy = 0.1 × 4.18 × 6.0 = 2.5 kJ
7b	ΔH_r = (3 × -393.5) + (4 × -285.8) + 118.9 = -2204.8 kJ mol^{-1}

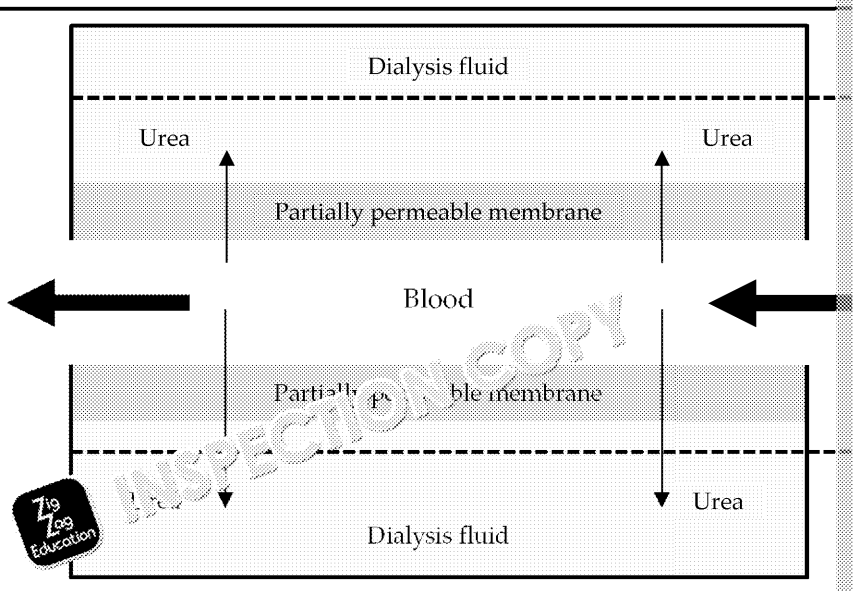
Question	Answer
1a	
1b	Bicuspid valve
1c	Sino-atrial node excites the left atrium Triggers atrioventricular node Conducts along bundle of His towards base of heart Passes along Purkinje fibres through ventricles
1d	Excitation originates within muscle tissue in myogenic muscle Skeletal muscle relies on excitation from motor nerve
1e	70 mL = 0.07 dm^3 0.07 × 112 = 7.84 dm^3 min^{-1}
1f	O blood group samples do not have ABO group antigens on the cell
2	Largest lumen Highly elasticated Site of diffusion High blood pressure One cell thick Contains valves Ca
3a	
3b	(Blood pressure is highest in the aorta) It decreases through the systemic arteries. It is at its lowest in capillaries. It increases slightly entering veins, but never reaches arterial pressure
4a	Tachycardia

Question	Answer	
4bi		
4bii	QRS represents depolarisation of the ventricles. This is the stage where blood is ejected from the heart.	
5a	Level 3 (5–6) – An extensive list of risk factors, with reasons suggested Level 2 (3–4) – An attempt at a list of risk factors, with some reasons suggested Level 1 (1–2) – Some risk factors mentioned, without mention of reasons Level 0 – No response, or none worthy of marks	Genetics – might code f related to CVD Age – old age leads to w and vessels Gender – men are at a h Diet – poor diet / obesit atherosclerosis and to d also lead to CVD High BP – can damage endothelium Smoking – leads to dep reducing their efficienc Inactivity – leads to hea loss of vessel efficiency
5b	*Two from:* • (Some are) unsuitable duri or pregnancy • (Some can) raise sodium / potassium / blood sugar levels • (Some can) cause impotence • (Some are) unsuitable for people with heart/liver/circulatory dis • (Some can) cause tiredness / slow heartbeat / diarrhoea / nausea • (Some can) disturb sleep	
6a	6 × 35 = 210 mg	
6b	Caffeine causes an increase in heart rate. This will eventually plateau, as the heart will be unable to physicall The *Daphnia* will die, or there will be insufficient substrates to facili contraction.	

Question	Answer
1	
2	They reduce friction (lubrication). They protect the lungs (cushioning).
3ai	Recoil of muscles causes ribcage to drop / move inwards and ribcage decrease
3aii	Contraction causes diaphragm to lower and ribcage volume to increase
3aiii	Causes air to be pushed out of the lungs
3b	Use a (mechanical) ventilator
4a	*Three from:* • Proximity to blood flow • Capillary walls one cell thick • Large surface area for diffusion • Tissues are moist • Steep diffusion gradient
4b	Oxygen
4c	**Vital capacity** Expiratory reserve + tidal volume + inspiratory reserve = 560 + 1200 + 3400 = 5160 mL **Total lung capacity** Residual volume + vital capacity = 5160 + 1200 = 6360 mL
4d	5 × 60 = 300 / 1.5 = 200 breaths in five minutes 200 × 560 = 112 000 mL of air
4e	Maximum speed of expiration *OR* Maximum expiratory force
4f	Vital capacity is how much air can fill the lungs. Peak expiratory flow is how quickly this air can be expelled.
5a	*Four from:* • Increased frequency of peaks or spikes per minute • Increased tidal volume • Increased breathing rate • Decreased inspiratory reserve volume • Decreased expiratory reserve volume • No change to vital capacity • No change to total lung volume
5b	Oxygen consumption is the amount of oxygen used. Tidal volume is the amount of air inhaled. As a result, both are positively correlated as increased oxygen consumption requires increased inhalation.

B3: Urinary system structure and function

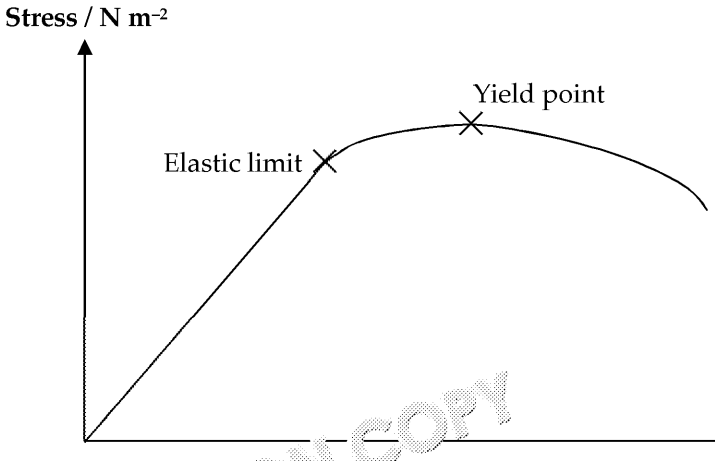
Question	Answer	
1a	Excretion of harmful/toxic breakdown products Osmoregulation (control of the water potential of blood)	
1bi	Bladder Storage of urine before elimination from the body	
1bii	Ureter Transport of urine from the kidney to the bladder	
1biii	Renal vein Deoxygenated, clean blood to the heart	
2a	Bowman's capsule surrounds the glomerulus Bowman's capsule collects the glomerular filtrate	
2b	Proximal convoluted tubule Glucose is rapidly lost in glomerular filtrate, and must be reabsorbed respiration	
2c	Loop of Henle	
2d	Level 3 (5–6 marks) A clear and methodical explanation covering most points Level 2 (3–4 marks) An attempt at explanation, but lacking methodical approach and many points absent Level 1 (1–2 marks) Some correct [illegible] but little [illegible] 0 No response, or none worthy of marks	• Hypothalamus detects water • ADH produced by the hypot secreted into the pituitary gla • When water potential is decr secreted into blood stream • ADH is carried to nephron • ADH causes channels that re or • Causes an increase in the am reabsorbed. • More concentrated urine • Less urine volume • Negative feedback • Upon increase in water poten secretion is stopped • Fewer channels open • Less water reabsorbed • Urine less concentrated • More urine volume
2e	Sodium (Na^+) Sodium (Na^+) Renin Angiotensin Constrict Increase Sodium (Na^+) Potassium (K^+)	
3a	Build-up of toxic pr[illegible]t[illegible]ioning of blood Unable to co[illegible]sorption / loss of useful substances	

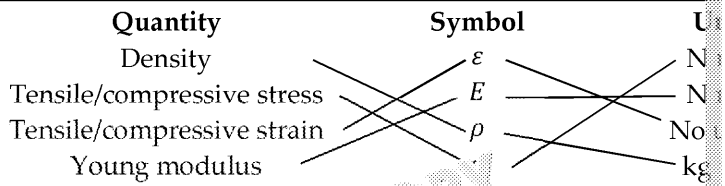
Question	Answer	Marks
3bi and ii		
3c	Concentration gradient must be present to remove urea from the blood	
3d	Three from: • Lack of available tissue for transplantation • Transplantation is more expensive • Greater risk from surgery for transplantation • Greater risk of rejection for transplantation • Dialysis easier to perform • Less skilled surgeons required for dialysis	

Question	Answer
1a	Form a bilayer Separating the fluids on the outside and inside of the membrane
1bi	Increased temperature
1bii	Increases its stability + (/prevents the cell from bursting)
1c	**Disagree:** The membrane is not a fluid, hence fluid mosaic model. **Agree:** Proteins (pores/channels) allow movement across membrane.
1d	Intrinsic proteins cross both layers of the bilayer. Extrinsic proteins are embedded in the bilayer but do not cross.
1e	Lipid soluble molecules are able to cross the lipid bilayer, entering c resistance. Lipid insoluble molecules require receptors/channels in order to ent meaning they are reliant on membrane proteins.
2a	Facilitated diffusion requires transmembrane / transport proteins / p Passive diffusion acts without transport proteins.
2b	*Two from:* • Solubility • Size • Polarity
2c	Osmosis
2d	*Two from:* • Does not require transport proteins • Water is able to cross the membrane • Water molecules are very small • Moves substances based on their concentration
3a	Active transport requires energy, which is provided by mitochondri
3b	Membrane changes shape Engulfs the bacterium Forms vesicle in which the bacterium is enclosed
3c	Hormones are not fat soluble Enclosed in vesicle to cross the membrane
4a	Amoeba: Volume = 50 × 50 × 90 = 225 000 Surface area = 2(50 × 50) + 2(50 × 90) + 2(50 × 90) = 23 000 Ratio = 23 000:225 000 = 1:9.78
4bi	Increasing size causes increased ratio. Increased ratio decreases transport efficiency. Greater sized animals have necessity for transport systems.
4bii	*One from:* Needs specialised organ. Needs specialised organ systems Needs a fluid / transport medium

Question	Answer
1ai	6.5 kW
1aii	3 200 000 W
1aiii	14 000 000 kW
1b	C. N m^{-2}
2a	A. The energy transferred to the object
2b	$\Delta W = F\Delta s$ $\Delta W = 8[illegible]$ $W = [illegible]$ J
2c	$= p\Delta v$ $p = \frac{\Delta W}{\Delta v}$ $p = \frac{3080}{3.60-1.40}$ $p = 1400$ Pa
3a	Converted into other forms of waste energy (such as heat and sou
3b	efficiency $= \frac{\text{useful energy output}}{\text{total energy input}}$ efficiency $= \frac{42}{75}$ efficiency $= 0.56$ (or 56 %)
4a	efficiency $= 1 - \frac{Q_{out}}{Q_{in}}$ efficiency $= 1 - \frac{59}{660}$ efficiency $= 0.91$ (or 91 %)
4b	efficiency = [illegible] [illegible] $= 1 - \frac{340}{550}$ [illegible]iency $= 0.38$ (or 38 %)
5a	Energy cannot be created or destroyed, only converted between different forms.
5b	input energy = light energy + heat energy heat energy = input energy − light energy heat energy = 500 − 470 heat energy = 30 J
5c	efficiency $= \frac{\text{useful energy output}}{\text{total energy input}}$ efficiency $= \frac{470}{500}$ efficiency $= 0.94$ (or 94 %)
6	$pV = NkT$ $T = 38$ °C $= 31$[illegible] K $p = \frac{NkT}{V}$ $p = \frac{9.[illegible] \times 10^{23} \times 1.38 \times 10^{-23} \times 311}{0.77}$ $p = 5500$ Pa
7a	D. A change of state

Question	Answer
7b	A. Free expansion of an ideal gas
8a	The heat into a system is equal to the sum of the work done on the change in internal energy of the system. ($\Delta Q = \Delta U + \Delta W$)
8b	$\Delta Q = \Delta U + \Delta W$ $\Delta Q = 35 + 27$ $\Delta Q = 62$ J
9a	In order: no ch ma o
9b	The disorder (entropy) of a system will always increase over time.
9c	Heat cannot be transferred into work perfectly due to disorder inc
10ai	It converts thermal energy into work / kinetic energy by heating a gas (or liquid) which expands (and does work).
10aii	*One from:* • Car engine • Power plant • Piston
10b	It cools a gas/liquid by allowing the gas/liquid to do work by expanding which decreases the internal energy (and t rature).
10c	Heat pump
10d	(The maximum theo c efficient of performance is) the highe of heat supp a fraction of the work required.
11a	ter ar forces between molecules weaken. etic energy of molecules remains constant.
11b	No heat is transferred between the objects when in contact.
12a	How much heat is required to induce a change in the system
12b	$\Delta Q = mc\Delta T$ $\Delta Q = 1.30 \times 4.18 \times 10^3 \times (86.0 - 10.0)$ $\Delta Q = 413$ kJ
12c	Can absorb a lot of energy without a large increase in temperature
12d	$\Delta Q = \Delta mL$ $\Delta m = \frac{\Delta Q}{L}$ $\Delta m = \frac{615 \times 10^3}{243 \times 10^3}$ $\Delta m = 2.53$ kg
12e	Can absorb a lot of energy with u ch g state

Question	Answer
1a	The ability of an object to return to its original shape after being de
1b	*One from:* • Flexible seals • Bandages • Wet suits • Allow any [illegible] which requires a change of shape
2a	How [illegible] object deforms for a given force [illegible]h gradient shows little deformation (and vice versa)
2b	1 mark for elastic limit marked at end of linear section 1 mark for yield point marked at turning point of curved section 
2c	How well th[illegible]ri[illegible]esists deformation due to an applied force
2d	[illegible]e [illegible]section is elastic. [illegible] curved section is plastic.
3a	Creep is from stress from constant forces (i.e. weight). Fatigue is stress from repetitive motion.
3b	B. Drawing the material into a wire
3c	Brittle materials fracture easily under stress so a structure will collapse.
3d	*One from:* • Ceramics • Moulds • Temporary uses (e.g. holding something in place) • Can be moulded into shape (useful for tools, etc.)
3e	(As a rubber band is stretched) the differe[illegible]lecules rub against causing internal friction. This causes energy to be di[illegible]ea as heat; so that the rubber ban[illegible] not return to its exact original shape.
3f	Hyst[illegible]

Question	Answer
4	
5	$= \frac{m}{V}$ ρ $V = \frac{0.550}{1.44}$ $V = 0.382\ \text{m}^3$
6a	$F = kx$ $x = \frac{F}{k}$ $x = \frac{350}{5.95 \times 10^3}$ $x = 58.8 \times 10^{-3}\ \text{m}$
6b	$\sigma = \frac{F}{A}$ $A = \frac{F}{\sigma}$ $A = \frac{350}{32.2 \times 10^6}$ $A = 1.09 \times 10^{-5}\ \text{m}^2$
6c	$\varepsilon = \frac{\Delta x}{x}$ $\varepsilon = \frac{0.0588}{0.280}$ $\varepsilon = 0.210$
7a	$E = \frac{\sigma}{\varepsilon}$ $E = \frac{F/A}{\Delta x/x}$ $E = \frac{Fx}{A\Delta x}$
7b	$E = \frac{Fx}{A\Delta x}$ $A = \frac{Fx}{E\Delta x}$ $A = \frac{415 \times 30.0 \times 10^{-2}}{210 \times 10^6 \times (34.5 \times 10^{-2} - 30.0 \times 10^{-2})}$ $A = 1.32 \times 10^{-5}\ \text{m}^2$
8a	$\Delta E_{el} = \frac{1}{2} F \Delta x$ $F = \frac{2\Delta E_{el}}{\Delta x}$ $F = \frac{2 \times 2.25}{8.40 \times 10^{-2}}$ $F = 53.6\ \text{N}$
8b	$\Delta E_{el} = \frac{1}{2} F \Delta x$ $F = k\Delta x$ $\Delta E_{el} = \frac{1}{2} k \Delta x \Delta x$ $\Delta E_{el} = \frac{1}{2} k (\Delta x)^2$
8c	$\Delta x = \sqrt{\frac{2\Delta E_{el}}{k}}$ $\Delta x = \sqrt{\frac{2 \times 1.34}{710}}$ $\Delta x = 0.0614\ \text{m}$

Question	Answer
1a	Flow A: turbulent Because flow is irregular Flow B: streamlined Because flow is smooth
1b	Flow A Vortices and eddies cause an increase in resistive forces.
1c	*Any two from:* • Speed of fluid flow • Velocity of object • Viscosity of fluid • Temperature of fluid
1d	C. When stirring is needed
1e	The rate of flow is constant at all points along the pipes.
2a	The object in fluid B The more viscous fluid (fluid A) will exert greater resistive forces a of the object Slowing the object
2b	The object would fall more quickly as a higher temperature will decrease viscosity and decrease resistive forces against the falling object.
2c	The object would stop when it hit the surface. The object would then sink through the fluid as non-Newtonian fluids act like solids when large forces are exert
3a	Rate of flow increases with decreased pressure.
3b	Air flow increases pressure of the gas. Due to Bernoulli's principle, this causes a reduction in the rate of f
3c	Air has to move more quickly over the top of the wing than below to maintain air flow speed around the wing. This causes a lower pressure above the wing which causes a resultant upthrust force.