BTEC

Pearson BTEC Level 3 National in Applied Science

Unit 5: Principles and Applications of Science II

Sample Assessment Materials (SAMs)

For use with Diploma and Extended Diploma in Applied Science

First teaching from September 2016 **Issue 1**

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BTEC

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Write your name here

Surname	Forename

Learner Registration Number | Centre Number | Level 3

Applied Science

Unit 5: Principles and Applications of Science II

Diploma, Extended Diploma in Applied Science

Sample assessment material for first teaching September 2016 onwards

Time: 2 hours

You must have:
Calculator, ruler

Total marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – there may be more space than you need.

Information

- The total mark for this paper is 120.
- The paper is comprised of three sections worth 40 marks each.
  - Section A: Organs and Systems.
  - Section B: Properties and Uses of Substances.
  - Section C: Thermal Physics, Materials and Fluids.
- The marks for **each** question are shown in grey boxes
  – use this as a guide as to how much time to spend on each question.
- The Periodic Table of Elements and formulae sheet can be found at the back of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Paper reference
XXXX/XX
S50608A

S 5 0 6 0 8 A 0 1 4 0

Turn over ▶

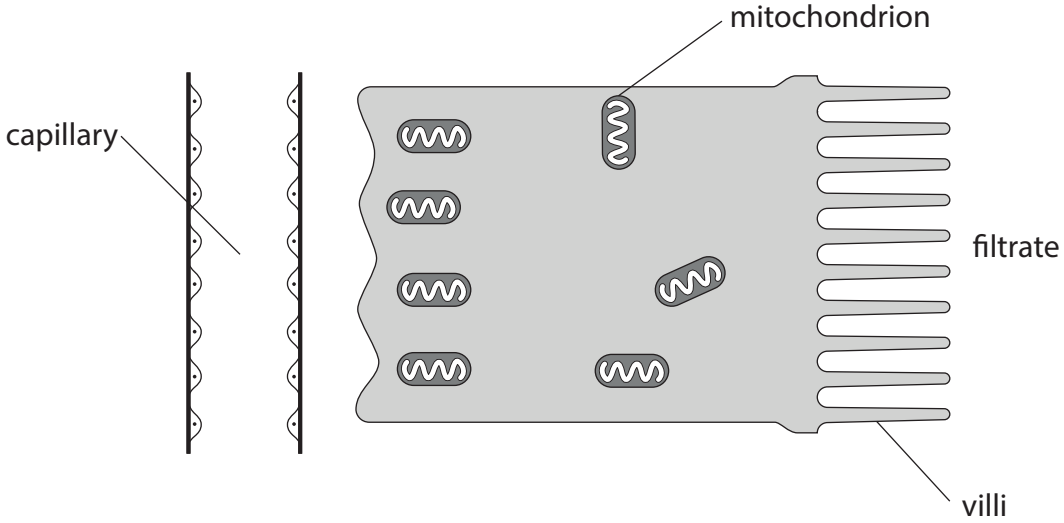
PEARSON

SECTION A: Organs and systems

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The diagram shows a cell found in the wall of the proximal convoluted tubule in a kidney.



(a) Name the process used to reabsorb water from the filtrate into the blood.

1 mark

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(b) State **two** ways in which the cell in the diagram is adapted to reabsorb glucose.

2 marks

1 .....

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2 .....

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Total for Question 1 = 3 marks

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2 A scientist investigated the surface area of capillary walls in three different organs.

The table shows the surface area of the capillary walls in one gram of tissue for three different organs.

Organ	Surface area/cm^2 g^{-1}
Brain	500
Lung	3500
Muscle	100

(a) (i) Suggest a reason for the difference in the surface area of capillary walls in the brain and the capillary walls in the muscle.

1 mark

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(ii) Give a reason why the lung has the greatest surface area.

1 mark

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The mass of a lung is 1.3 kg.

(iii) Calculate the total surface area of the capillaries in this lung.

2 marks

Show your working.

Total surface area = ... cm^2

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The table shows the diameter of the aorta and a capillary.

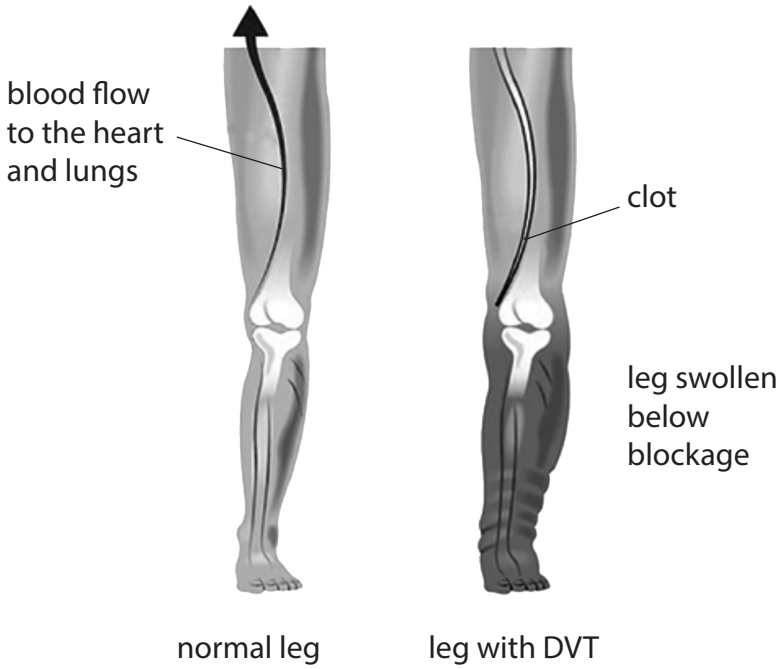
Diameter of blood vessel/mm	
Aorta	Capillary
25.0	0.008

(b) Explain why there is a difference in the diameter of the aorta and the capillary.

4 marks

Deep vein thrombosis (DVT) can be a risk to people who travel for several hours by aeroplane.

A blood clot forming in leg veins can cause a blockage. This can cause the leg to swell as shown in the diagram.



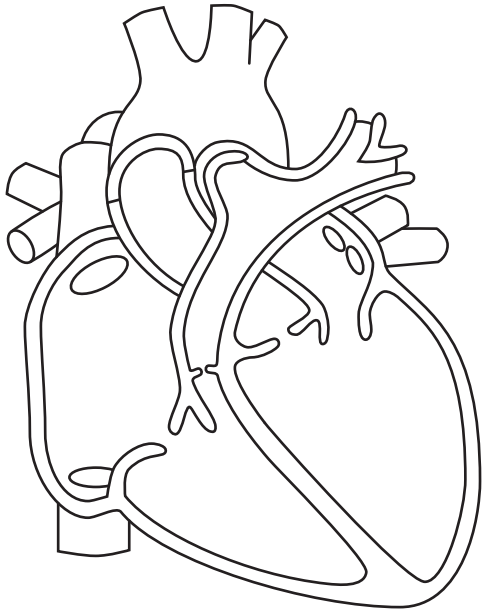
(Source: http://www.theexpertinstitute.com/expert-witness/dvt/)

(c) Explain why passengers are advised to walk around during a flight that takes several hours.

3 marks

Total for Question 2 = 11 marks

3 The diagram shows the human heart.



(a) (i) Label with an X on the diagram the location of the sinoatrial node.

1 mark

(ii) Which of the following is a function of the sinoatrial node?

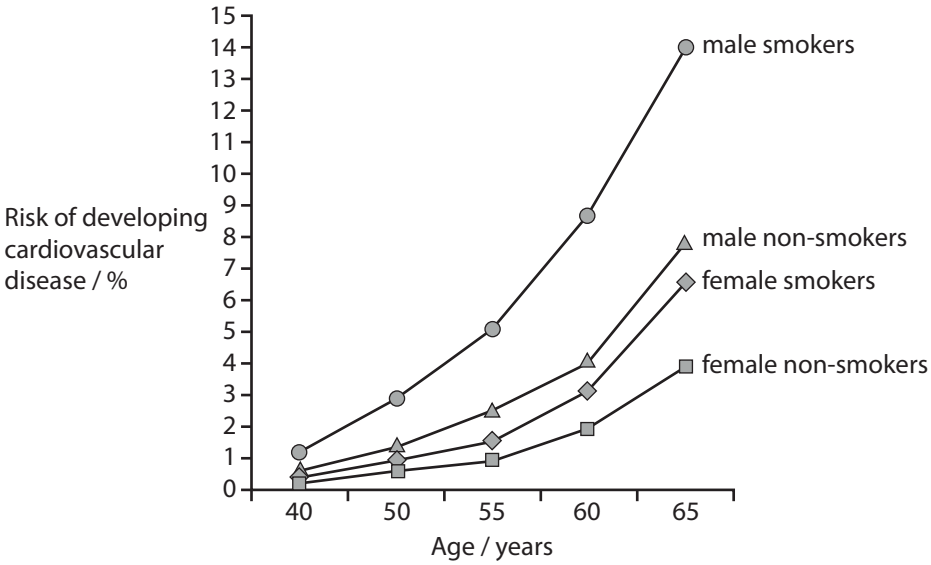
1 mark

- ☒ **A** prevents backflow into the ventricles
- ☒ **B** prevents backflow into the atria
- ☒ **C** sends signals to the atrioventricular node
- ☒ **D** receives signals from the atrioventricular node

Cardiovascular disease caused one in three deaths in the UK in 2014.

In a study, the effect that certain factors have on the risk of developing cardiovascular disease was measured.

The graph shows the results.

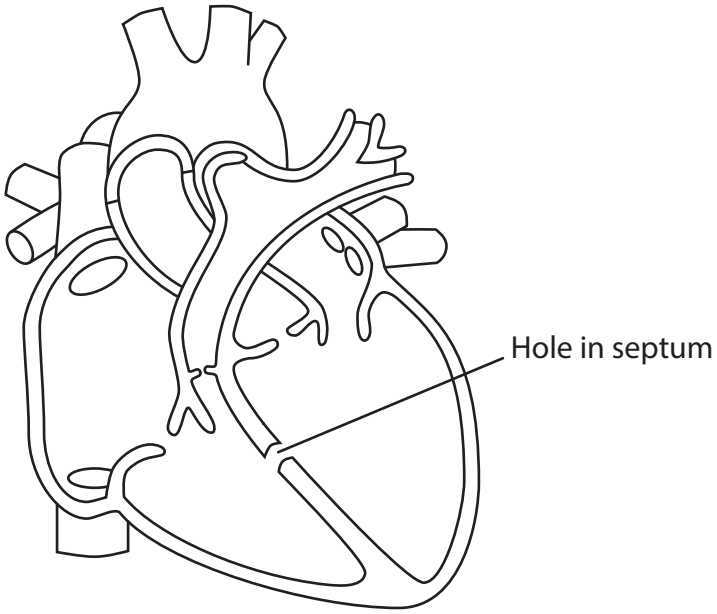


(b) Compare how the different factors affect the risk of developing cardiovascular disease.

4 marks

The heart of a fetus has a different structure to the heart of an adult.

A fetal heart has a hole in the septum between both ventricles, as shown in the diagram.



At birth, this hole closes but in some babies the hole remains open.

(c) Explain why a hole in the septum may cause a baby to tire more quickly.

4 marks

Total for Question 3 = 10 marks

4 Breathing in and out requires the use of muscles to change the volume of the thorax.

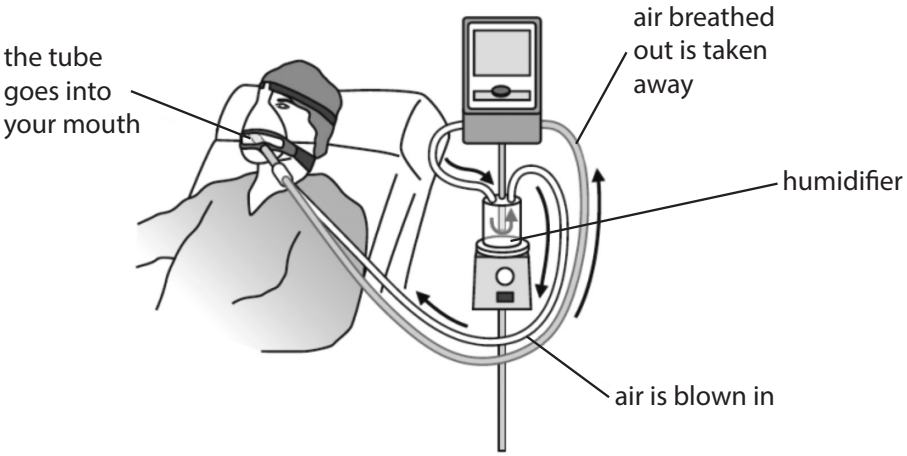
(a) Which row of the table correctly describes the action of each muscle when breathing in?

1 mark

		Diaphragm	External intercostal
☒	**A**	contracts	contracts
☒	**B**	contracts	relaxes
☒	**C**	relaxes	contracts
☒	**D**	relaxes	relaxes

Sometimes, people are unable to breathe for themselves. They need to be attached to a machine called a ventilator. The machine moves air in and out of the lungs.

The diagram shows a person on a ventilator.



(Source: Cancer Research UK)

(b) (i) Explain why the exhaled air is taken away.

2 marks

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(ii) Give a reason why a humidifier is used.

1 mark

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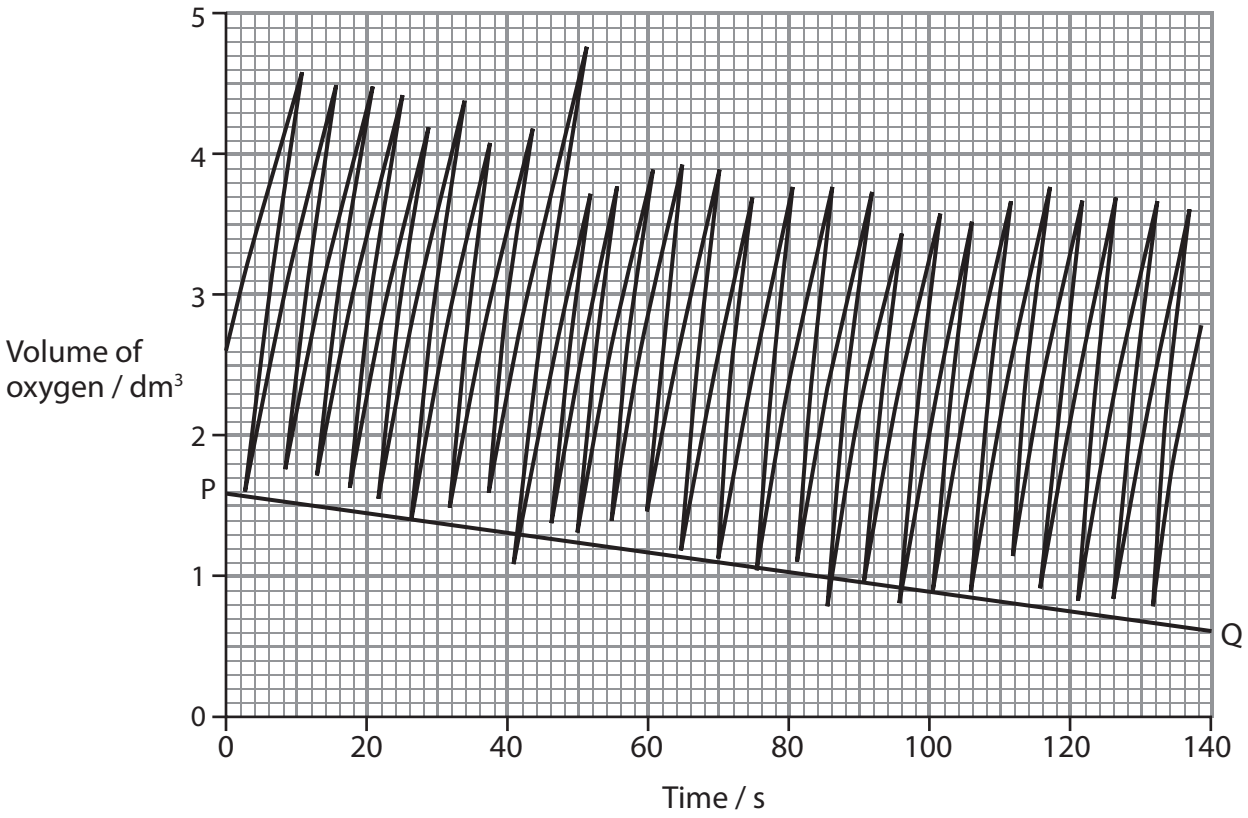
A spirometer can be used to measure human breathing rate and oxygen consumption.

The diagram shows a spirometer trace obtained from a person during a period of exercise.



(c) (i) State the name given to the distance between each peak and each trough on this spirometer trace.

1 mark

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(ii) State the breathing rate of this person in breaths min^{-1}.

1 mark

.....

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The person had a body mass of 80 kg and consumed 0.4 dm^3 min^{-1} of oxygen.

(d) Calculate the rate of oxygen used by this person in dm^3 kg^{-1} h^{-1}

2 marks

Show your working.

Rate of oxygen = ... dm^3 kg^{-1} h^{-1}

(e) Give **two** ways how a trace obtained during a period of exercise would differ from a trace obtained during a period of rest.

2 marks

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Total for Question 4 = 10 marks

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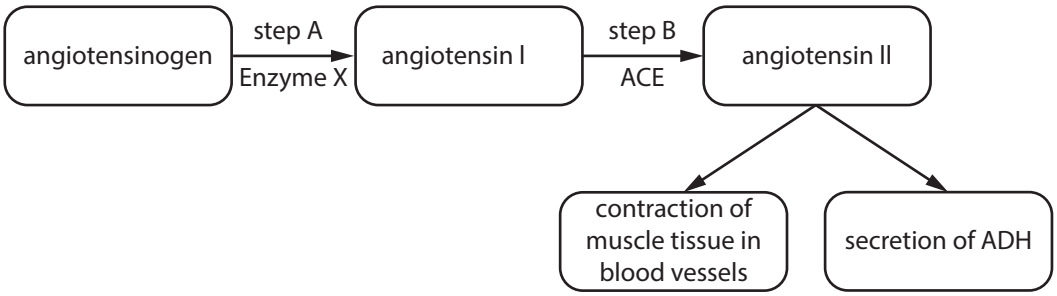
5 The kidney is involved in the control of blood pressure.

High blood pressure is a health risk.

The diagram shows steps involved in the control of blood pressure.

Step A is controlled by enzyme X. Step B is controlled by angiotensin converting enzyme (ACE).



Inhibitors prevent enzymes from working.

Explain how an ACE inhibitor can help people with high blood pressure.

Total for Question 5 = 6 marks

END OF SECTION

TOTAL FOR SECTION A = 40 MARKS

SECTION B: Properties and Uses of Substances

Answer ALL questions. Write your answers in the spaces provided.

6 The alkanes and the alkenes are two families of organic compounds obtained from crude oil. Commercially they are an important source of fuels and raw materials for the manufacture of polymers.

Propane, C_3H_8, is an alkane and a fuel.

(a) Draw the displayed formula for propane.

1 mark

Pentane has the molecular formula C_5H_{12}

Pentane has structural isomers.

(b) State the number of isomers of pentane that are saturated compounds.

1 mark

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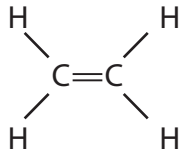
Ethene can be used to make materials for plastic bags and bottles.



(c) (i) State how the structure of ethene shows it is an unsaturated molecule.

1 mark

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Thermal cracking can be used to produce alkenes such as ethene from long chain alkanes.

(ii) Describe how temperature affects the length of the alkene molecules produced.

2 marks

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(iii) Explain why it is useful to crack long chain alkanes obtained from crude oil.

2 marks

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The free radical polymerisation of ethene produces poly(ethene), which is a material used to make plastic bags and bottles.

There are three stages to the free radical polymerisation of ethene; initiation, propagation and termination.

(d) (i) Explain how organic peroxides are involved in the initiation stage of the free radical polymerisation of ethene.

2 marks

(ii) Describe the propagation and termination stages in this reaction.

4 marks

Propagation .....

Termination .....

Total for Question 6 = 13 marks

7 Transition metals and their compounds are used in many industrial processes because of their catalytic properties.

(a) State **two** other characteristic properties of transition metals.

2 marks

1 .....

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2 .....

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Vanadium(V) oxide is used as a catalyst in the contact process to make sulfuric acid.

(b) (i) Use equations to help explain how vanadium(V) oxide acts as a catalyst in the contact process.

4 marks

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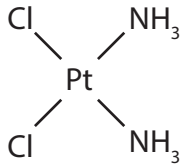
(ii) Explain why impurities in the reactants can cause problems in the contact process.

2 marks

Transition metal complexes can be used in medicine.

The diagram shows a complex that can be formed by platinum. This complex is used in an anti-cancer drug.



(c) Explain **two** reasons why transition metals are able to easily form complex ions.

4 marks

1

2

Total for Question 7 = 12 marks

8 Alkanes are a source of energy that are burned in camping gas burners.

The combustion of butane is shown by the equation:

$C_4H_{10(g)} + 6\frac{1}{2}\ O_2 \rightarrow 4CO_{2(g)} + 5H_2O_{(l)}\ \Delta H_c^{-\ominus} = -2874\ kJ\ mol^{-1}$

(a) (i) Draw an enthalpy level diagram for the combustion of butane.

2 marks

(ii) State how you can tell from the equation that the reaction is exothermic.

1 mark

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Butane is used (burnt) to heat 10 kg of water.

(iii) Calculate the temperature rise of the water if 0.5 mol butane is used.

Assume the butane is burned under ideal conditions and all the energy is transferred to the water.

Change in energy = mass × specific heat capacity × change in temperature

[Specific heat capacity of water is 4.18 kJ kg^{-1} K^{-1}]

3 marks

Show your working.

Temperature = ... k

The formation of butane is shown by the equation:

$$4C_{(s)} + 5H_{2(g)} \rightarrow C_4H_{10(g)}$$

The standard enthalpy of formation of butane is –126.5 kJ mol^{-1}

The standard enthalpies of combustion for carbon and butane are given in the table.

	Standard enthalpy of combustion / kJ mol^{-1}
$C_{(s)}$	–394
$C_4H_{10(g)}$	–2874

(b) Calculate the standard enthalpy of combustion for hydrogen.

3 marks

Show your working.

k = ... kJ mol^{-1}

Total for Question 8 = 9 marks

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9 Titanium is a metal that has many useful properties. However, it is used only in small quantities for specialised purposes such as the making of hip replacement joints. This is because the extraction of titanium from titanium oxide, TiO_2, is expensive.

The industrial process to extract titanium involves the following reactions:

$$TiO_{2(s)} + 2Cl_{2(g)} + C_{(s)} \rightarrow TiCl_{4(g)} + CO_{2(g)}$$

$$TiCl_{4(g)} + 2Mg_{(l)} \rightarrow Ti_{(s)} + 2MgCl_{2(s)}$$

Explain why this process is so expensive.

Total for Question 9 = 6 marks

END OF SECTION

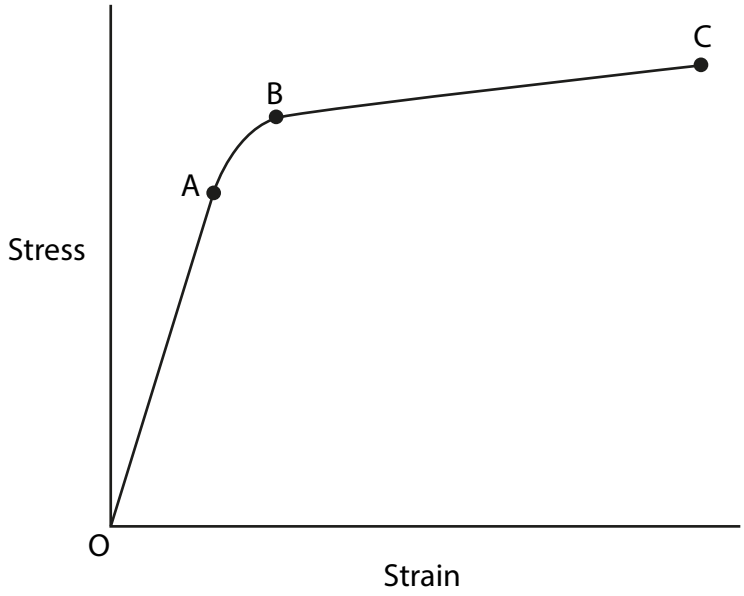
TOTAL FOR SECTION B = 40 MARKS

SECTION C: Thermal Physics, Materials and Fluids

Answer ALL questions. Write your answers in the spaces provided.

10 How springs behave depends on the properties of the metal from which they are made.

The sketch graph shows the relationship between stress and strain for a ductile wire which is being stretched.



(a) (i) State the relationship shown in region OA.

1 mark

.....

.....

(ii) State what happens to the wire at point B.

1 mark

.....

.....

(iii) Describe what is happening to the wire between B and C.

2 marks

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(iv) State what happens to the wire at point C.

1 mark

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The picture shows a spring used in the suspension system of a car. There are four of these springs on a car.

When the car is loaded evenly with a weight of 3200 N, each spring is compressed by 0.05 m.

(Source: http://www.gerrickscustom.com/suspension-service.html)

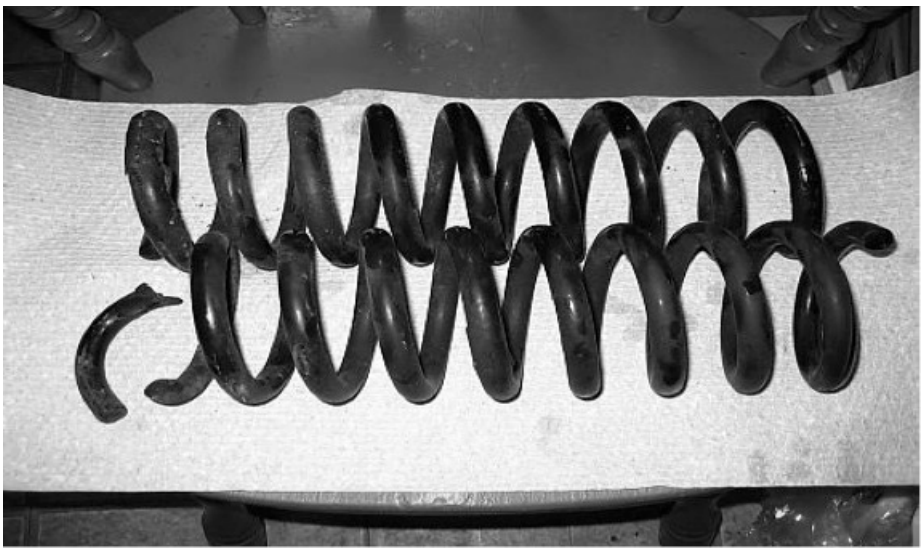
(b) Calculate the spring constant, *k*, for one of these springs and state the unit.

3 marks

Show your working.

k = ...

The photograph shows a spring that has failed due to fatigue.



(Source: http://www.benzworld.org/forums/w210-e-class/1453862-broken-coil-spring.html)

(c) Describe how fatigue occurs.

3 marks

Total for Question 10 = 11 marks

11 The first law of thermodynamics for an ideal gas can be written as:

$$\Delta Q = \Delta U + \Delta W$$

Q is the heat entering the system, W is the work done by the system.

(a) (i) Give the meaning of the symbol ΔU.

1 mark

(ii) If the change in the system is adiabatic, explain what happens to the value of Q.

2 marks

(b) Explain how the second law of thermodynamics applies to heat engines.

2 marks

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(c) An air-conditioning company advertises that their heat pumps can be used to 'create a comfortable environment in any room all through the year'.

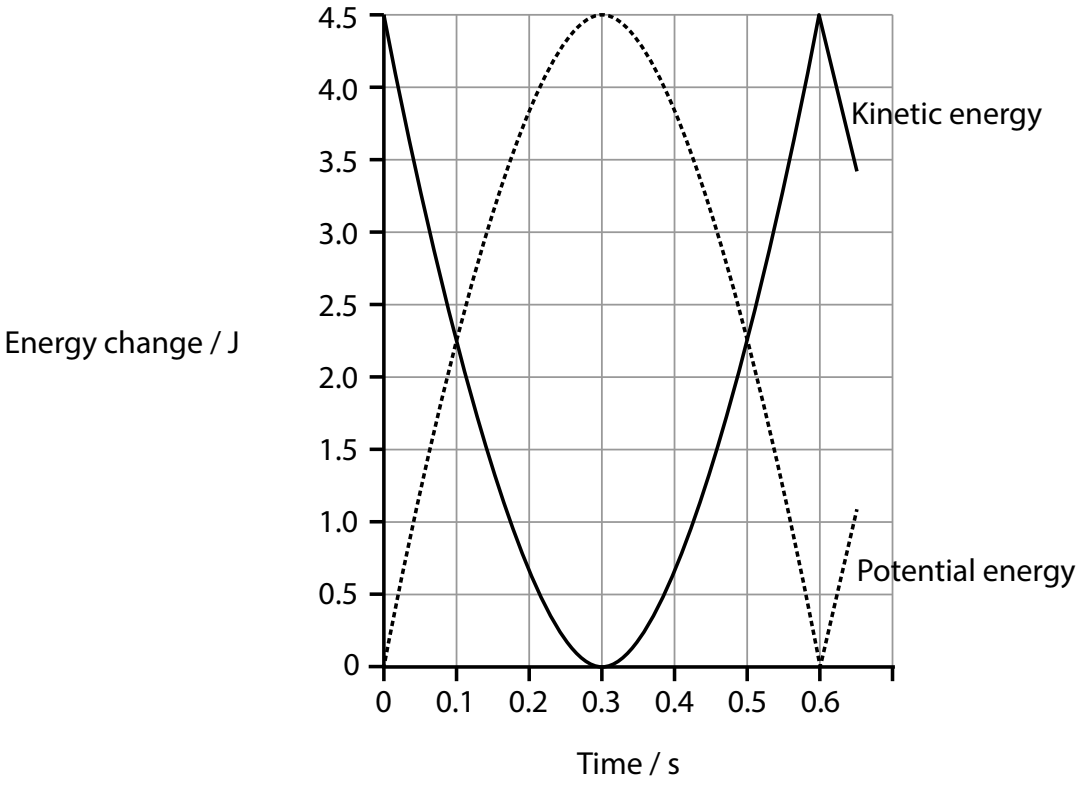
Explain how this can be done by considering the way that a heat pump works.

4 marks

Total for Question 11 = 9 marks

12 When objects move up and down their energy changes from one form to another.

The graph shows the energy changes that occur when a ball has just been thrown upwards.



Using the graph

(a) (i) Calculate the rate at which the potential energy changes.

1 mark

Show your working.

Rate = ... J s^{-1}

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(ii) Give a reason why the potential energy is zero at 0.6 s.

1 mark

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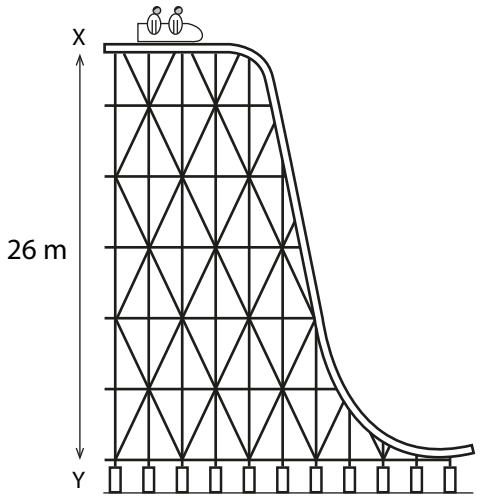
The diagram shows a fairground ride with a car moving very slowly at X.
The car and the passengers have a total mass of 570 kg.
X is 26 m above the bottom of the ride, Y.



(b) (i) Show that the gravitational potential energy, GPE, of the car and its passengers at X is about 1.5×10^5 J.

2 marks

Show your working.

GPE ..... J

As the car travels from X to Y only 80% of the potential energy is transferred into kinetic energy.

(ii) State what has happened to the other 20% of the potential energy.

1 mark

.....

.....

(iii) Calculate the velocity of the car and passengers when they reach Y and state the unit.

4 marks

Show your working.

Velocity of the car at Y = ...

Total for Question 12 = 9 marks

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13 (a) State what is meant by latent heat of vaporisation.

1 mark

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A saucepan contains 0.6 kg of water at 20°C.
Heat is transferred to the water at a rate of 2500 W.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}.
Specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}.

(b) Calculate how long it will take for the water to boil away, leaving the saucepan dry.

4 marks

Show your working.

Time = ... s

Metal	Specific heat capacity /J $kg^{-1}K^{-1}$	Density /kg m^{-3}	Melting point /°C	Approximate relative cost per m^3
Aluminium	897	2700	660	1.4
Copper	385	8900	1084	11.5
Cast Iron	449	7850	1149	1.4

(c) Using information from the table, comment on which metal is the most suitable for making a saucepan.

6 marks

Total for Question 13 = 11 marks

END OF EXAM

TOTAL FOR SECTION C = 40 MARKS
TOTAL FOR PAPER = 120 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Formulae Sheet

Work $\Delta W = F\Delta s$

Work done by a gas $\Delta W = p\Delta v$

Efficiency $\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$

Efficiency for heat engines $\text{efficiency} = 1 - \frac{Q_{out}}{Q_{in}}$

Maximum theoretical efficiency $\text{efficiency} = 1 - \frac{T_c}{T_H}$

Thermodynamics

Ideal gas equation $pV = NkT$

First law of thermodynamics $\Delta Q = \Delta U + \Delta W$

Specific heat capacity $\Delta Q = mc\Delta T$

Specific latent heat $\Delta Q = \Delta mL$

Materials

Density $\rho = \frac{m}{\text{V}}$

Hooke's law $F = k\Delta x$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$$\Delta E_{el} = \frac{1}{2} F\Delta x$$

Unit 5: Principles and Applications of Science II – sample mark scheme

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first learner in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Learners must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks, if the learner's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a learner's response, the team leader must be consulted.
- Crossed-out work should be marked, UNLESS the learner has replaced it with an alternative response.
- You will not see 'or words to that effect' (OWTTE). Alternative correct wording should be credited in every answer, unless the mark scheme has specified specific wording that must be present.
- Round brackets () indicate words that are not essential, e.g. '(hence) distance is increased'.
- Error carried forward (ECF), means that a wrong answer given in an earlier part of a question is used correctly to a later part of a question.
- / indicates that the responses are alternatives and either answer should receive full credit.

Specific marking guidance for levels-based mark schemes*

Levels-based mark schemes (LBMS) have been designed to assess learners' work holistically. They consist of two parts: indicative content, and levels based descriptors. Indicative content reflects specific content-related points that a learner might make. Levels-based descriptors articulate the skills that a learner is likely to demonstrate, in relation to the assessment outcomes being targeted by the question. Different rows in the levels, represent the progression of these skills.

When using a levels-based mark scheme, the 'best fit' approach should be used.

- Examiners should first make a holistic judgement on which band most closely matches the learner's response and place it within that band. Learners will be placed in the band that best describes their answer.
- The mark awarded within the band will be decided based on the quality of the answer, in response to the assessment focus/objective and will be modified according to how securely all bullet points are displayed at that band.
- Marks will be awarded towards the top or bottom of that band, depending on how they have evidenced each of the descriptor bullet points.

Section A – Organs and systems

Question number	Answer	Additional guidance	Mark
1(a)	• osmosis		(1)

Question number	Answer	Additional guidance	Mark
1(b)	• contains mitochondria that produce ATP for active uptake of glucose **(1)** • have villi/microvilli/projections that increase the surface area **(1)**		(2)

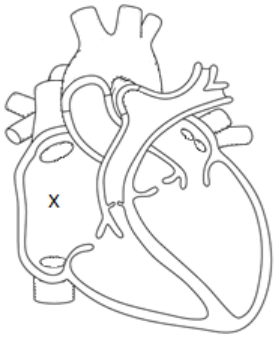
Question number	Answer	Additional guidance	Mark
2(a)(i)	• brain has more surface area because nerve cell activity requires lots of oxygen/better supply of oxygen/more respiration		(1)

Question number	Answer	Additional guidance	Mark
2(a)(ii)	• because it is used to absorb oxygen from the air needed by all the other organs		(1)

Question number	Answer	Additional guidance	Mark
2(a)(iii)	• substitution **(1)** 1300×3500 • answer **(1)** 4 550 000 (cm^2)		(2)

Question number	Answer	Additional guidance	Mark
2(b)	An explanation that makes reference to the following points: • capillaries are smaller because involved with gas exchange **(1)** • (and) need to be thin/one cell thick/ endothelium only for short diffusion distance of gases **(1)** • aorta is larger because wall contains muscle/elastic tissue **(1)** • to withstand blood arriving from the left ventricle at high pressure **(1)**		**(4)**

Question number	Answer	Additional guidance	Mark
2(c)	An explanation that makes reference to the following points: • walking causes muscles to squeeze leg veins **(1)** • (therefore) blood flow to continue **(1)** • (therefore) less risk of swelling/blood clots/blood failing to reach organs **(1)**		**(3)**

Question number	Answer	Additional guidance	Mark
3(a)(i)	X clearly placed in right atrium **(1)**. 		**(1)**

Question number	Answer	Additional guidance	Mark
3(a)(ii)	• C (sends signals to the atrioventricular node)		**(1)**

Question number	Answer	Additional guidance	Mark
3(b)	A comparison that includes at least one similarity and one difference from the following points. Similarities: • smoking increases the risk of developing cardiovascular disease **(1)** • as you get older, the risk of developing cardiovascular disease increases **(1)** Differences: • males have a greater risk of developing cardiovascular disease than females **(1)** • combination of two or more variables **(1)**, e.g. oldest male smokers are most at risk/youngest female non-smokers are least at risk **(1)** • comparison of the variables, e.g. youngest male smoker less at risk than oldest male non-smoker **(1)**		**(4)**

Question number	Answer	Additional guidance	Mark
3(c)	An explanation that makes reference to the following points: • blood from left ventricle mixes with blood from right ventricle (contains deoxygenated blood) **(1)** • (there is) less oxygenated blood in the vessels transported (to muscles) **(1)** • (so) less respiration **(1)** • less energy/manufacture of ATP **(1)**		**(4)**

Question number	Answer	Additional guidance	Mark
4(a)	• A (contracts/contracts)		**(1)**

Question number	Answer	Additional guidance	Mark
4(b)(i)	An explanation that makes reference to the following points: • exhaled air contains carbon dioxide **(1)** • (and carbon dioxide) is toxic/affects breathing rate **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
4(b)(ii)	• (moisten the air) to avoid dehydration/ gases need to be in solution to be able to diffuse		**(1)**

Question number	Answer	Additional guidance	Mark
4(c)(i)	• tidal volume		**(1)**

Question number	Answer	Additional guidance	Mark
4(c)(ii)	• 12–13 (breaths min^{-1})		**(1)**

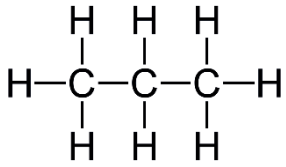
Question number	Answer	Additional guidance	Mark
4(d)	• substitution **(1)** $0.4 \times 60 \div 80$ • answer **(1)** 0.3 ($dm^3\ kg^{-1}\ h^{-1}$)		**(2)**

Question number	Answer	Additional guidance	Mark
4(e)	Any two from the following points: • peaks larger/tidal volume higher **(1)** • more peaks/breathing rate higher **(1)** • steeper slope **(1)**		**(2)**

Question number	Indicative content
5	Answers will be credited according to the learner's demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content but learners should be rewarded for other relevant answers. • an ACE inhibitor stops ACE working • less angiotensin II • muscle in blood vessels relaxes • reduced secretion of ADH from pituitary • collecting duct is impermeable • blood vessels contain more blood • less reabsorption of water into blood • lower blood pressure • lower risk of heart disease/live longer, blood vessels remain wide/widen • blood vessels contain more blood • more urine produced

Mark scheme (award up to 6 marks) refer to the guidance on the cover of this document for how to apply levels-based mark schemes*.		
Level	**Mark**	**Descriptor**
	0	no rewardable content
Level 1	1–2	• demonstrates adequate knowledge of scientific facts/concepts, with generalised comments made • generic statements may be presented rather than linkages being made, so that lines of reasoning are unsupported or partially supported • the explanation shows some structure and coherence
Level 2	3–4	• demonstrates good knowledge and understanding by selecting and applying some relevant scientific knowledge facts/concepts to provide the discussion being presented • lines of argument mostly supported through the application of relevant evidence • the explanation shows a structure that is mostly clear, coherent and logical
Level 3	4–6	• demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of scientific facts/concepts to provide the discussion being presented • line(s) of argument consistently supported throughout by sustained application of relevant evidence • the explanation shows a well-developed structure that is clear, coherent and logical

Section B – Properties and Uses of Substances

Question number	Answer	Additional guidance	Mark
6(a)			(1)

Question number	Answer	Additional guidance	Mark
6(b)	• five		(1)

Question number	Answer	Additional guidance	Mark
6(c)(i)	• it has a carbon-carbon double bond		(1)

Question number	Answer	Additional guidance	Mark
6(c)(ii)	A description that makes reference to the following points: • at higher temperatures, the long chain molecules break near the end **(1)** • the higher the temperature, the shorter the alkene molecules/the higher the proportion of short chain alkenes **(1)**	Allow converse description for lower temperatures.	(2)

Question number	Answer	Additional guidance	Mark
6(c)(iii)	An explanation that makes reference to the following points: • surplus of long chain alkanes **(1)** • (cracking) produces alkenes which are in high demand (but low supply) **(1)**		(2)

Question number	Answer	Additional guidance	Mark
6(d)(i)	An explanation that makes reference to the following points: • (organic peroxides) contain oxygen-oxygen single bonds **(1)** • which break easily to give free radicals/ very reactive and form free radicals **(1)**		**(2)**

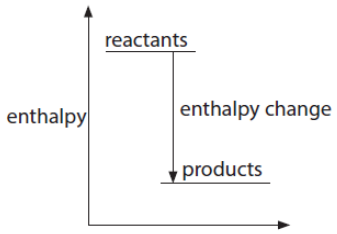
Question number	Answer	Additional guidance	Mark
6(d)(ii)	A description that makes reference to the following points: Chain propagation Any two from: • free radical hits ethene molecule, forming longer free radical **(1)** • the free radical, Ra•, uses one of the electrons in the pi/double bond (between carbon atoms), to help to form a new bond (between itself and one carbon atom) **(1)** • the other electron returns to the other carbon **(1)** Chain termination: • two free radicals hit each other producing a final molecule **(1)** • reaction stops as no free radicals formed to react **(1)**	Ra• + $CH_2 = CH_2$ → $RaCH_2CH_2$• $RaCH_2CH_2$• + $CH_2 = CH_2$ → RaH_2CH_2 CH_2CH_2•, etc. $Ra(CH_2)_m$ • + •$(CH_2)_nRa$ → $Ra(CH_2)_m(CH_2)_nRa$	**(4)**

Question number	Answer	Additional guidance	Mark
7(a)	Any two from: • can exist in variable oxidation state **(1)** • can form complex ions **(1)** • form coloured compounds/ions **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
7(b)(i)	An explanation that makes reference to the following: • $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ (1) • the variable oxidation state (of vanadium) allows a different route with a lower (activation) energy **(1)** • $V_2O_4 + \frac{1}{2} O_2 \rightarrow V_2O_5$ **(1)** • Vanadium(V) oxide produced again ready to catalyse (the next reaction) **(1)**	In either order.	**(4)**

Question number	Answer	Additional guidance	Mark
7(b)(ii)	An explanation that makes reference to the following points: • (impurities) deactivate the catalyst/block active sites **(1)** • (therefore) less product formed **(1)**	Accept reduces surface area (of active site)/ poisons the catalyst.	**(2)**

Question number	Answer	Additional guidance	Mark
7(c)	An explanation that makes reference to two of the following pairs: • ligand uses lone pair electrons **(1)** to form dative covalent bond **(1)** • transition metals are small **(1)**, so have a relatively high charge density **(1)** • transition metal atoms can use their 3d and 4s orbitals for bonding **(1)**, so can accept lone pair of electrons **(1)**		**(4)**

Question number	Answer	Additional guidance	Mark
8(a)(i)	• Reactants higher than products **(1)**. • Arrow pointing down and labelled $\Delta H_c^{\ominus}$/ −2847 kJ mol^{-1} **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
8(a)(ii)	• the negative enthalpy change	Accept negative/minus sign.	**(1)**

Question number	Answer	Additional guidance	Mark
8(a)(iii)	• Substitution **(1)** $\frac{2874}{2} = 10 \times 4.18 \times$ change in temperature • rearrangement **(1)** change in temperature = $\frac{1437}{10 \times 4.18}$ • Answer **(1)** • 34.38 (K)	Maximum of 2 marks if do not recognise 0.5 mols.	**(3)**

Question number	Answer	Additional guidance	Mark
8(b)	• Substitution **(1)** $-126.5 - 2874 = 4(-394) + 5(H_2)$ • Rearrangement **(1)** $\frac{-126.5 - 2874 + 1576}{5} = (H_2)$ • Answer **(1)** -285 (kJ mol^{-1})	Incorrect sign, maximum of 2 marks.	**(3)**

Question number	Indicative content
9	Answers will be credited according to the learner's demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content but learners should be rewarded for other relevant answers. • the titanium oxide ore needs to be concentrated • the chlorine for the (first stage) process, needs to be manufactured • titanium(IV) chloride reacts violently with water, so conditions need to be controlled carefully • energy needs to be supplied to initiate the (first) reaction • the titanium(IV) chloride produced, requires purification (by fractional distillation) • the magnesium for the (second stage) process, needs to be manufacture • energy needs to be supplied to initiate the (second) reaction • oxygen/nitrogen impurities make titanium brittle, so need to be excluded • the second/reduction stage has to be carried out in an argon atmosphere (which is costly) • the second/reduction stage is slow/takes two days/is time-consuming (which adds to costs) • separation of the titanium from the magnesium chloride (requires high temperatures/vacuum distillation), is costly in energy and equipment • to turn the titanium sponge produced into ingots (for manufacturers), involves arc melting/uses expensive electricity • (overall) the process involves several steps that make it slow/time consuming/more costly • (overall) it is a batch process, and therefore leads to less efficient/more costly production

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Section C – Thermal Physics, Materials and Fluids

Question number	Answer	Additional guidance	Mark
10(a)(i)	• stress is proportional to strain	Allow (obeying) Hooke's Law.	**(1)**

Question number	Answer	Additional guidance	Mark
10(a)(ii)	• yield point		**(1)**

Question number	Answer	Additional guidance	Mark
10(a)(iii)	A description that makes reference to the following points: • no longer elastic/plastically deforming **(1)** • will not return to original shape/ permanent deformation **(1)**	Allow layers of atoms slide over each other.	**(2)**

Question number	Answer	Additional guidance	Mark
10(a)(iv)	• Breaking point		**(1)**

Question number	Answer	Additional guidance	Mark
10(b)	• Calculation of weight of one spring **(1)** $\frac{3200}{4}$ • Substitution and transposition **(1)** $\frac{800}{0.05}$ • Answer **(1)** $1.6 \times 10^4\ \text{Nm}^{-1}$	Allow $16\,000\ \text{Nm}^{-1}$ Maximum 2 marks if k calculated for all four springs. Allow $16\,000\ \text{Nm}^{-1}$ Final mark awarded only if units given.	**(3)**

Question number	Answer	Additional guidance	Mark
10(c)	A description that makes reference to the following points: • continual loading and unloading/repeated working **(1)**. Plus any two from: • stress builds up at cracks **(1)** • cracks get bigger **(1)** • brittle fracture **(1)**	Allow continual vibration.	**(3)**

Question number	Answer	Additional guidance	Mark
11(a)(i)	• gain in internal energy (of gas)		**(1)**

Question number	Answer	Additional guidance	Mark
11(a)(ii)	An explanation that makes reference to the following points: • it remains the same **(1)** • (because) no heat enters or leaves the system **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
11(b)	An explanation that makes reference to the following points: • no heat engine can be 100 per cent efficient **(1)** • (because) some heat must be transferred from a warmer body to a cooler body **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
11(c)	An explanation that makes reference to the following points: • heat pumps use energy to transfer heat/provide or remove heat/transfer heat from a cold to a hot reservoir **(1)** • heat pumps use a refrigerant/compressor, vaporiser and condenser **(1)** • refrigerant vapour condensed to liquid to give out heat (to room or outside) **(1)** • system reversible/gives heat in winter cools in summer **(1)**		**(4)**

Question number	Answer	Additional guidance	Mark
12(a)(i)	• $\frac{4.5}{0.3} = 15$ (J s^{-1})		**(1)**

Question number	Answer	Additional guidance	Mark
12(a)(ii)	• the ball hits the ground/returns to original height	Accept 'is caught'.	**(1)**

Question number	Answer	Additional guidance	Mark
12(b)(i)	• substitution **(1)** (GPE) = $570 \times 9.81 \times 26$ • answer **(1)** 1.45×10^5 (J)		**(2)**

Question number	Answer	Additional guidance	Mark
12(b)(ii)	• dissipation of energy/friction/drag		**(1)**

Question number	Answer	Additional guidance	Mark
12(b)(iii)	• percentage calculation **(1)** $0.8 \times 1.45 \times 10^5$ • substitution **(1)** $1.16 \times 10^5 = \frac{1}{2} \times 570 \times v^2$ • transposition **(1)** $\sqrt{\frac{2.32 \times 10^5}{570}} = v$ • answer **(1)** $20.2\ \text{ms}^{-1}$ Or • percentage calculation **(1)** $0.8 \times 1.45 \times 10^5$ $mgh = \frac{1}{2} mv^2$ **(1)** $\sqrt{2gh = v}$ **(1)** • answer **(1)** $20.2\ \text{ms}^{-1}$	Allow 1.5×10^5 for potential energy. Final mark awarded only if units given.	**(4)**

Question number	Answer	Additional guidance	Mark
13(a)	• heat needed to change a substance from a liquid to a vapour/gas, at a constant temperature	Allow water and steam and the boiling point.	**(1)**

Question number	Answer	Additional guidance	Mark
13(b)	• $\Delta Q = mc\Delta T + mL$ **(1)** • substitution (ΔQ =) $0.6 \times 4200 \times 80 + 0.6 \times 2.26 \times 10^6$ **(1)** • calculation of total heat energy 1.56×10^6 (J) **(1)** • answer $\frac{1.56 \times 10^6}{2500} = 623$(s) **(1)**	Must include $\Delta T = 80$ Allow 1 557 600 (J) Allow 623.04(s)	**(4)**

Question number	Indicative content
13(c)	Answers will be credited according to the learner's demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content but learners should be rewarded for other relevant answers. **Specific heat capacity** • low SHC means a quick transfer of heat • copper and cast iron have a lower specific heat capacity than aluminium, so they are better to use **Density** • lower density means that a material is lighter • aluminium is best to use, as it is easiest to handle Melting point • a higher melting point means that the pan will withstand high heat from the flames • copper and cast iron are more suitable **Cost** • lower cost of the metal, makes it cheaper to make • aluminium and cast iron are cheap **Judgement** • a decision on which pan should be chosen, between cast iron and copper, based on the evidence in the table

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Level 2	3–4	• good analysis, interpretation and/or evaluation of the scientific information • lines of argument mostly supported through the application of relevant evidence • a judgement is made that is supported by evidence
Level 3	4–6	• comprehensive analysis, interpretation and/or evaluation of all pieces of scientific information • line(s) of argument consistently supported throughout by sustained application of relevant evidence • a judgement is made that is fully supported by evidence

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