Write your name here

Surname	Other names

Pearson BTEC Level 3 Nationals Diploma

Centre Number

Learner Registration Number

Applied Science

Unit 5: Principles and Applications of Science II

Thursday 25 January 2018 – Morning
Time: 2 hours 30 minutes

Paper Reference
31627H

You must have:
Calculator

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*.
- You must attempt all **three** sections but you may complete them in any order.

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 (Biology). Starts on page 3.
  Section B: Properties and uses of substances (Chemistry). Starts on page 16.
  Section C: Thermal physics, materials and fluids (Physics). Starts on page 27.
- The marks for **each** question are shown in brackets – *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.

Turn over ▶

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Pearson

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Applied Science

Unit 5: Principles and Applications of Science II

Biology

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 ☒.

SECTION A: ORGANS AND SYSTEMS

1 Figure 1.1 shows part of the respiratory system.

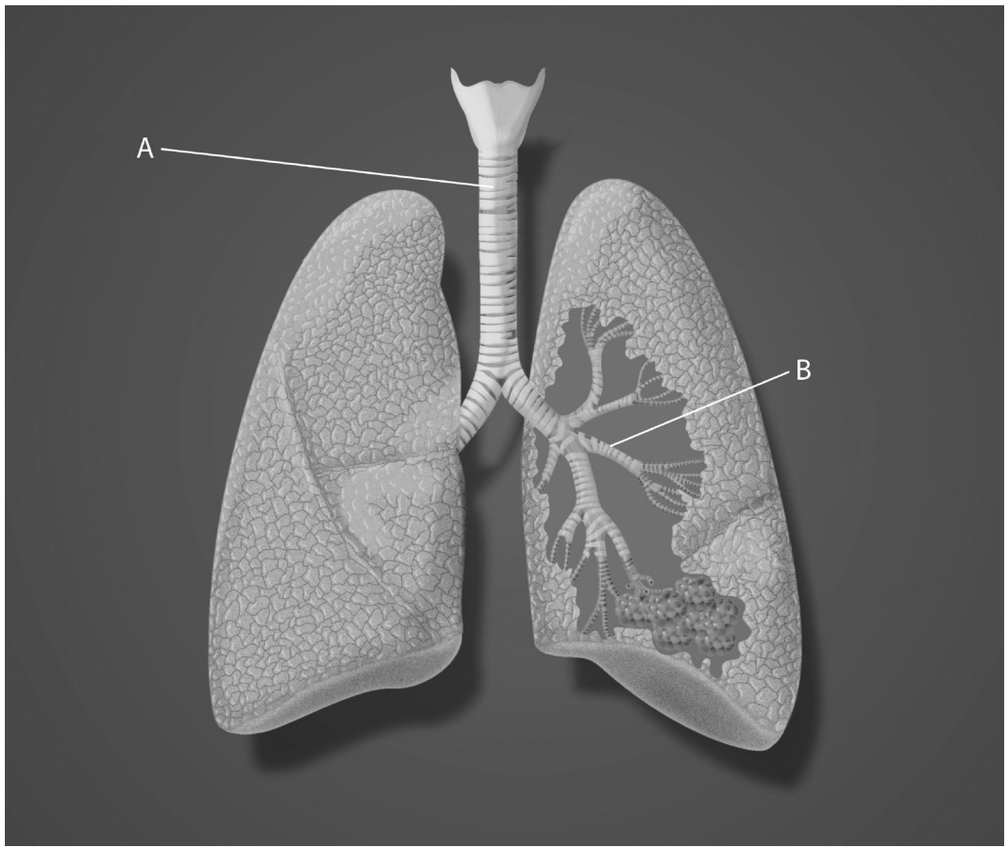

Figure 1.1

(a) (i) Identify the name of structure A in Figure 1.1

(1)

- ☒ **A** alveoli
- ☒ **B** bronchus
- ☒ **C** larynx
- ☒ **D** trachea

(ii) Name the structure labelled B in Figure 1.1

(1)

.....

(b) Paragraph 1.1 describes the volume and pressure changes that occur in the thorax during expiration.

During expiration, the external intercostal muscles ..A.. and the ribcage moves down and in. The diaphragm moves up. This causes the volume to ..B.. and the pressure to ..C.. inside the thorax.

Paragraph 1.1

(i) Identify the missing word A in Paragraph 1.1.

(1)

.....

(ii) Identify the missing word B in Paragraph 1.1.

(1)

.....

(iii) Identify the missing word C in Paragraph 1.1.

(1)

.....

(c) Figure 1.2 shows a peak flow meter.

Peak flow meters measure the speed of expiration.

Doctors can use peak flow meters to help diagnose patients with asthma.

Figure 1.2

Figure 1.3 shows a peak flow rate graph of a patient with asthma before and after treatment.

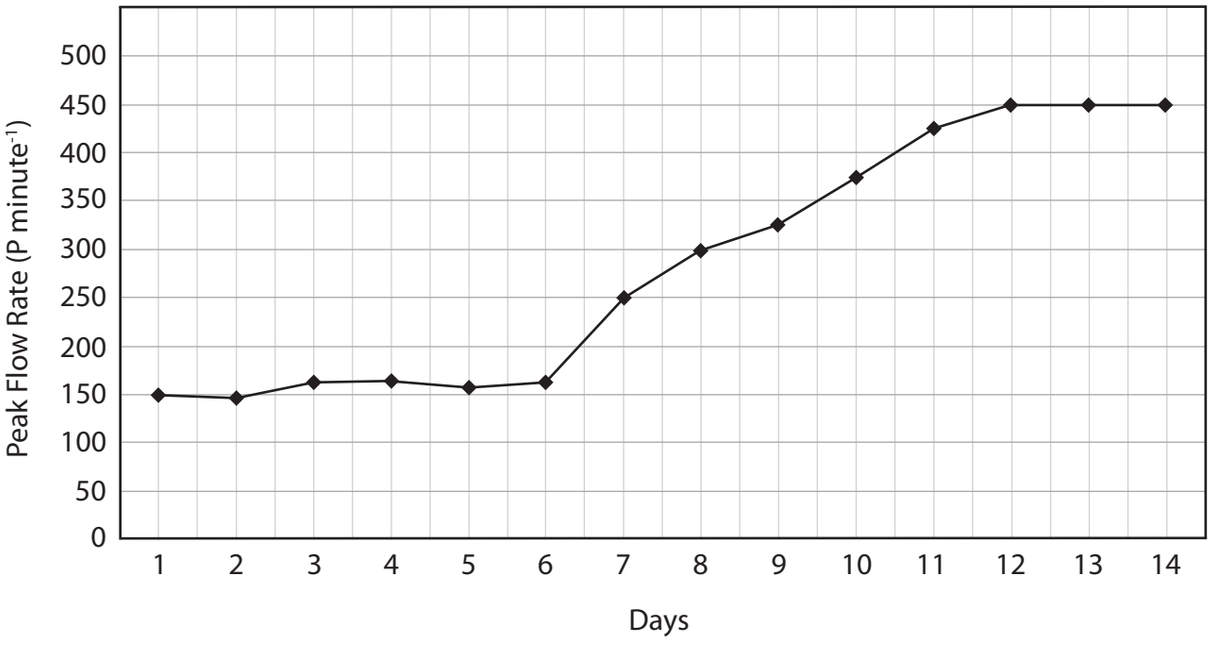

Figure 1.3

(i) Identify the day on which the treatment for asthma began.

(1)

- ☒ **A** day 2
- ☒ **B** day 6
- ☒ **C** day 10
- ☒ **D** day 12

(ii) Calculate the percentage increase in peak flow rate between day 1 and day 14.

(2)

Show your working.

..... %

(Total for Question 1 = 8 marks)

2 Figure 1.4 shows the structure of a cell surface membrane.

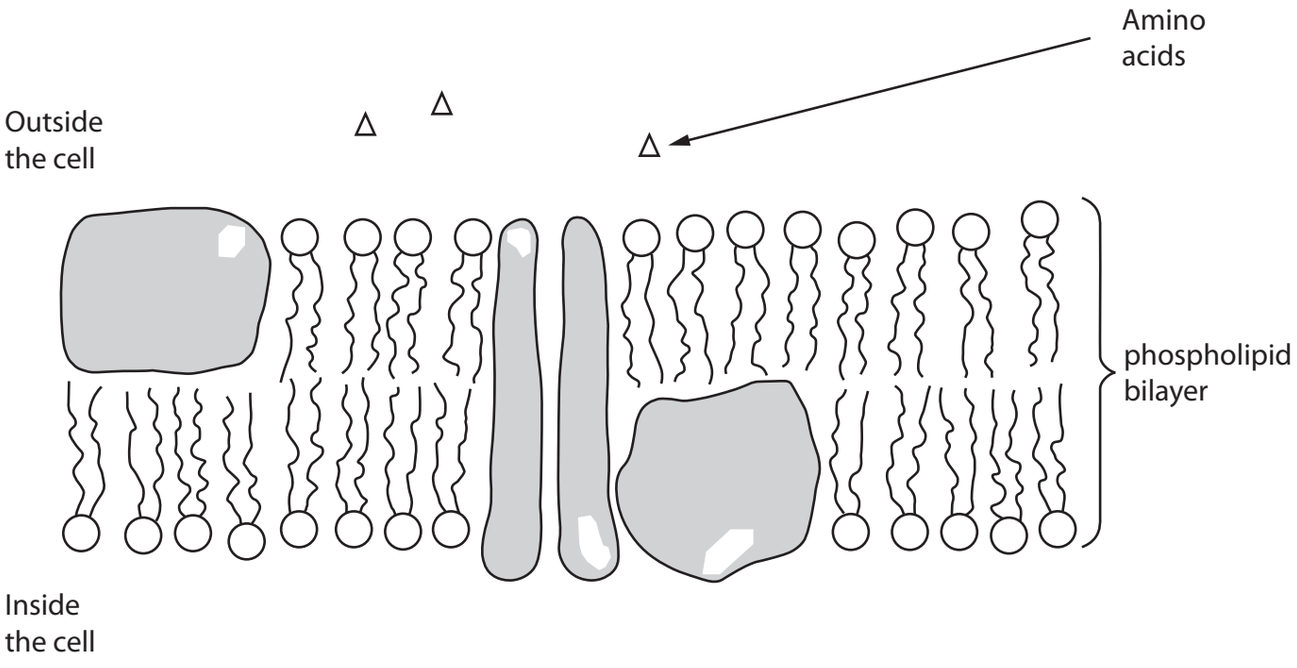

Figure 1.4

(a) Amino acids are required inside the cell for protein synthesis. Amino acids cannot pass through the phospholipid bilayer.

Describe, using information from Figure 1.4, how the amino acids enter the cell.

(2)

.....

.....

.....

.....

Figure 1.5 shows the structure of a phospholipid molecule.

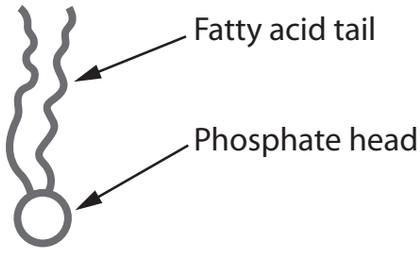

Figure 1.5

(b) (i) Explain how the properties of the phosphate head cause it to face the watery exterior and interior areas.

(2)

.....

.....

.....

.....

(ii) Explain how the properties of the fatty acid tails cause them to face away from the watery exterior and interior areas.

(2)

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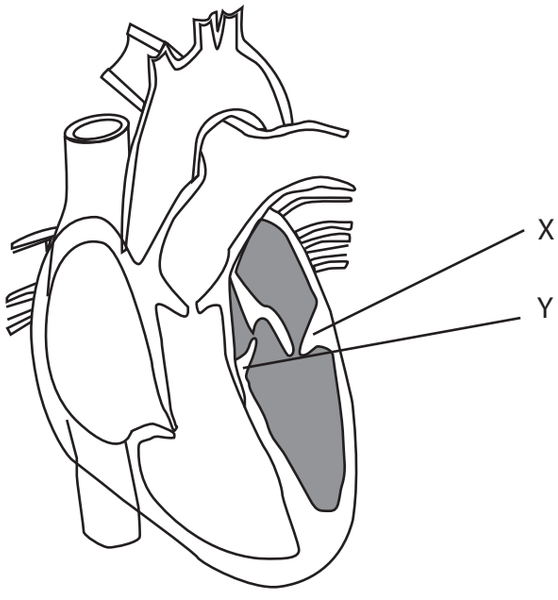
.....

.....

(Total for Question 2 = 6 marks)

3 (a) Figure 1.6 shows a section of the human heart.

X and Y are valves in the heart.



(Source: http://3.bp.blogspot.com/-IHW04Cn24RM/VAk5Rhmt_xI/AAAAAAAACpU/WoZJvUCloQc/s1600/Simple%2BHeart%2BDiagram.jpg)

Figure 1.6

(i) Name valves X and Y.

(2)

X .....

Y .....

(ii) Describe the function of the heart valves X and Y.

(3)

.....

.....

.....

.....

.....

.....

(b) There are changes in blood pressure during the cardiac cycle. These changes are brought about by the contraction and relaxation of heart muscle.

Table 1.1 refers to two phases of the cardiac cycle.

Complete Table 1.1 by stating whether the atria and ventricles are contracted or relaxed in each of these phases.

(2)

Phase of cardiac cycle	atria	ventricles
ventricular systole		
cardiac diastole		

Table 1.1

Figure 1.7 shows changes in blood pressure in the aorta and the left ventricle during the cardiac cycle.

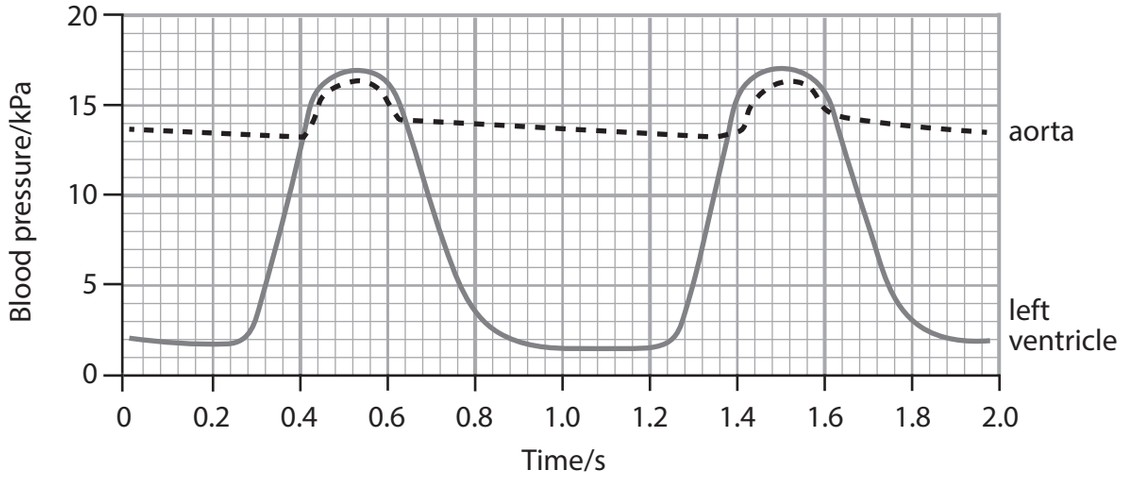


Figure 1.7

(c) Calculate the heart rate using information from Figure 1.7.

(3)

Show your working.

..... beats per minute

(d) Explain why during ventricular systole, the pressure in the right ventricle is different from the pressure in the left ventricle.

(3)

.....

.....

.....

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.....

.....

(Total for Question 3 = 13 marks)

4 The kidneys are organs of excretion and osmoregulation.

Patients with kidney failure may have dialysis to treat their condition.

During dialysis blood is taken out of the body and passed through a dialysis machine.

The dialysis machine contains partially permeable membranes that separate blood from dialysis fluid.

Figure 1.8 shows part of a dialysis machine.

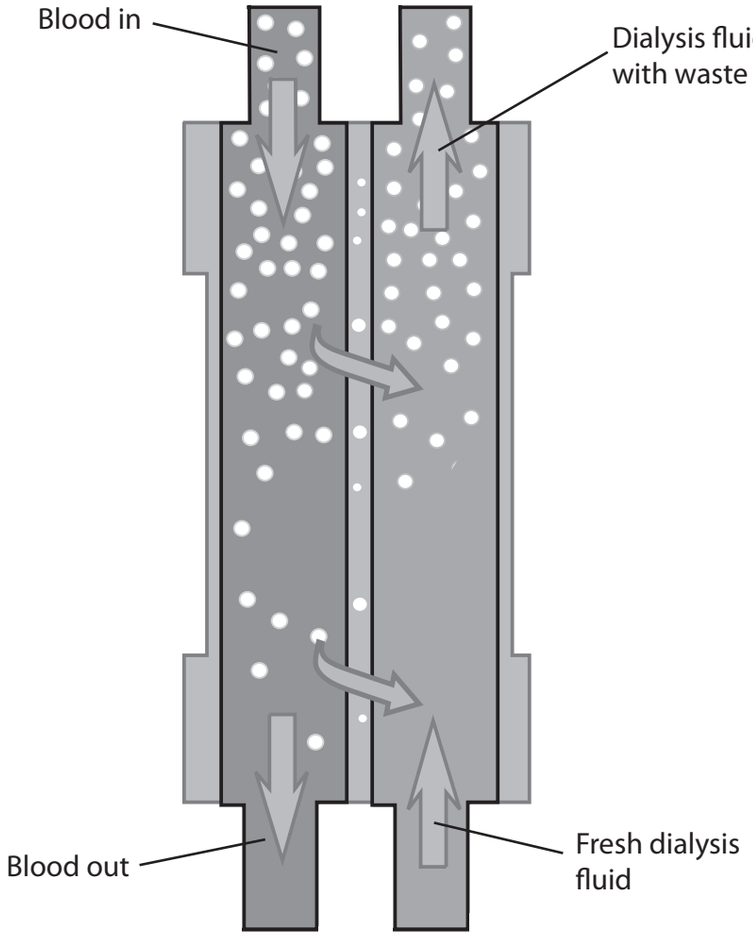


Figure 1.8

(a) Explain why the concentration of sodium ions in fresh dialysis fluid should be the same as the normal concentration of sodium ions in blood.

(3)

(b) The concentration of ions in blood plasma is continually monitored by osmoreceptors in an area of the brain.

When the concentration is too high, antidiuretic hormone (ADH) is released from the pituitary gland. The ADH is carried in the blood and acts on the kidneys.

Explain how ADH is involved in osmoregulation in the kidneys.

(4)

(Total for Question 4 = 7 marks)

5 Cardiovascular disease (CVD) affects the heart and blood vessels.

Coronary heart disease and strokes are types of cardiovascular disease.

High levels of low-density lipoprotein (LDL) cholesterol in the blood is one risk factor for CVD. Statins are one type of drug used to treat CVD.

Discuss the use of statins to treat CVD.

(Total for Question 5 = 6 marks)

TOTAL FOR SECTION A = 40 MARKS

Applied Science

Unit 5: Principles and Applications of Science II

Chemistry

SECTION B: PROPERTIES AND USES OF SUBSTANCES

SECTION B: PROPERTIES AND USES OF SUBSTANCES

6 Many metal oxides and metal hydroxides are basic.

(a) Identify the pH of a basic metal hydroxide solution.

(1)

- ☒ **A** pH 1
- ☒ **B** pH 4
- ☒ **C** pH 7
- ☒ **D** pH 10

(b) Aluminium oxide is an amphoteric metal oxide.

State what is meant by the term amphoteric.

(1)

.....

.....

(c) Sodium hydroxide is a base and an alkali.

Copper hydroxide is a base but not an alkali.

Give the reason why sodium hydroxide is an alkali but copper hydroxide is not.

(1)

.....

.....

(d) Manganese (IV) oxide is a transition metal compound.

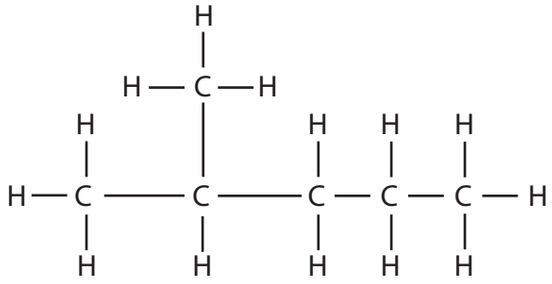
It can be used as a catalyst to speed up reactions.

Explain why manganese (IV) oxide can act as a catalyst.

(4)

(Total for Question 6 = 7 marks)

7 The properties of organic compounds depend on their structure and bonding.



(a) Name this compound using IUPAC convention.

(1)

.....

(b) C_4H_{10} has two structural isomers.

Complete the table to show the name and displayed formula of each isomer using IUPAC convention.

(4)

Name of isomer	Displayed formula

(c) State why hexane has a higher boiling point than methane.

(1)

.....

.....

(d) Alkenes are unsaturated hydrocarbons. Alkenes can be obtained by cracking.

(i) Identify the general formula for an alkene.

(1)

- ☒ **A** C_nH_{2n}
- ☒ **B** C_nH_{2n+2}
- ☒ **C** $C_{2n}H_n$
- ☒ **D** $C_{2n}H_{2n-2}$

(ii) Complete the equation for the cracking of decane to form **one** molecule of propene and one other organic molecule.

(2)

$$C_{10}H_{22} \longrightarrow \text{.....} + \text{.....}$$

(iii) Alkenes can have stereoisomers.

Explain why dichloroethene has cis- and trans- stereoisomers. You may use drawings to support your answer.

(2)

.....

.....

.....

.....

.....

.....

(iv) Alkanes contain sigma (σ) bonds.

Alkenes contain both sigma (σ) and pi (π) bonds.

Explain, in terms of sigma and pi bonds, why alkenes are more reactive than alkanes.

(4)

(Total for Question 7 = 15 marks)

8 Ethanol, C_2H_5OH, is often used as a biofuel.

It is a liquid at room temperature.

(a) (i) Write the balanced equation for the standard molar enthalpy change of formation of ethanol.

(3)

.....

(ii) Give **one** reason why the standard molar enthalpy change of formation of ethanol cannot be measured directly.

(1)

.....

.....

(b) The enthalpy change of combustion of ethanol was determined using a calorimeter.

The mass of the water used was 250 g.

The amount of ethanol burnt was 0.016 moles.

The initial temperature of the water was 293.0 K and the final temperature of the water was 303.5 K.

Specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

(i) Show that the heat energy produced by burning 0.016 moles of ethanol is approximately 10970 J.

Heat energy produced = mass of water × specific heat capacity × change in temperature.

Show your working.

(3)

Heat energy = ... J

(ii) The heat energy produced from burning 0.016 moles of ethanol is 10970 J.

Calculate the enthalpy change of combustion of ethanol in kJ mol^{-1}.

$$\Delta H = \frac{\text{heat energy produced}}{\text{number of moles}}$$

Show your working.

(3)

enthalpy change of combustion of ethanol = ... kJ mol^{-1}

(Total for Question 8 = 10 marks)

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9 Free radical reactions are important in the organic chemical industry.

Some polymers are made by the free radical polymerisation of alkenes.

(a) (i) Identify the type of reaction used in the free radical polymerisation of alkenes.

(1)

- ☒ **A** Addition
- ☒ **B** Hydration
- ☒ **C** Oxidation
- ☒ **D** Substitution

(ii) Draw **one** repeat unit of the polymer formed from the monomer $CH_2=CH_2$.

(1)

(b) Chloromethane is produced when chlorine reacts with methane.

Explain the **three** stages of the free radical mechanism involved in the formation of chloromethane.

(6)

(Total for Question 9 = 8 marks)

TOTAL FOR SECTION B = 40 MARKS

Applied Science

Unit 5: Principles and Applications of Science II

Physics

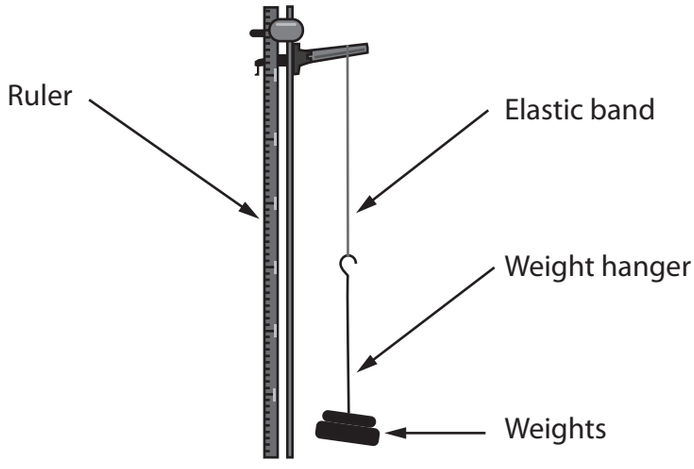
SECTION C: THERMAL PHYSICS, MATERIALS AND FLUIDS

SECTION C: THERMAL PHYSICS, MATERIALS AND FLUIDS

10 A force is applied to the end of an elastic band by adding weights.

The elastic band increases in length.

The increase in length is called the extension.

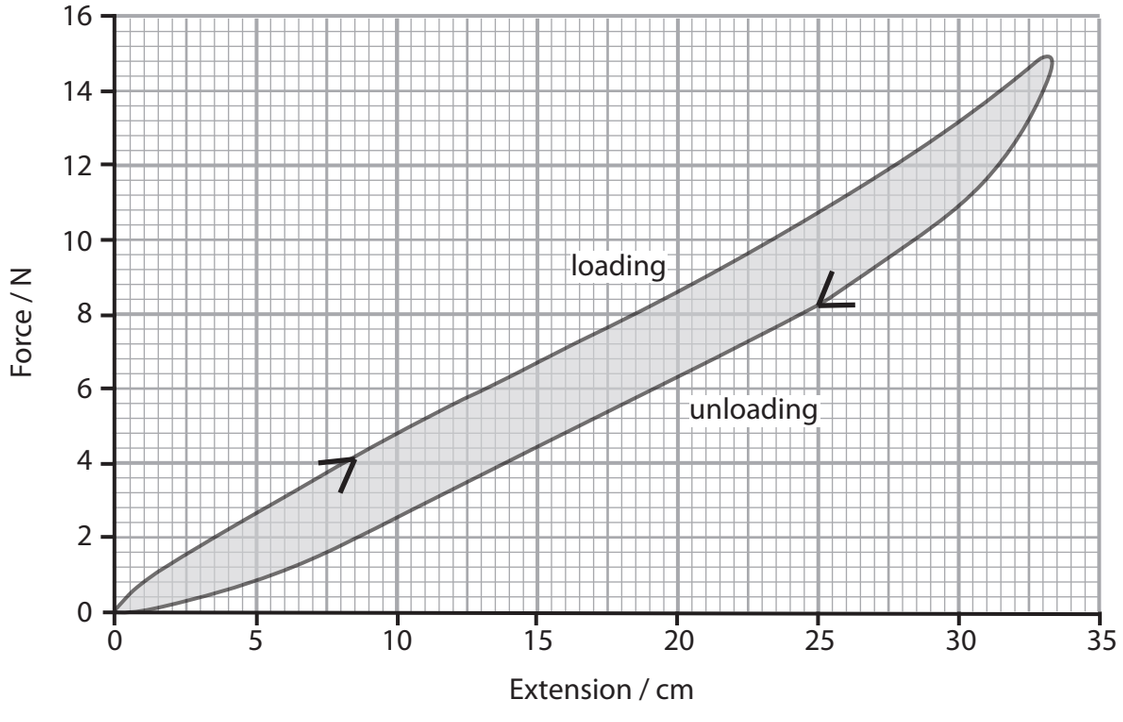


A learner measures the extension of the band.

This is repeated for a range of different weights.

The learner also measures the extension as the weights are removed.

They draw a graph of their results.



(a) Identify what the shaded area on the graph represents.

(1)

- ☒ **A** energy conserved by the elastic band
- ☒ **B** energy gained by the elastic band
- ☒ **C** energy lost by the elastic band
- ☒ **D** energy stored by the elastic band

(b) When all the weights are removed from the band, the line on the graph does not return to the origin.

Give the reason why the line on the graph does not return to the origin.

(1)

.....

.....

(c) Explain how the graph shows that the elastic band does not obey Hooke's law.

(2)

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(Total for Question 10 = 4 marks)

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11 A pipe is used to transport oil.

(a) Identify which factor will affect the pressure of the oil in the pipe.

(1)

- ☒ **A** density of the pipe wall
- ☒ **B** diameter of the pipe
- ☒ **C** length of the pipe
- ☒ **D** thickness of the pipe wall

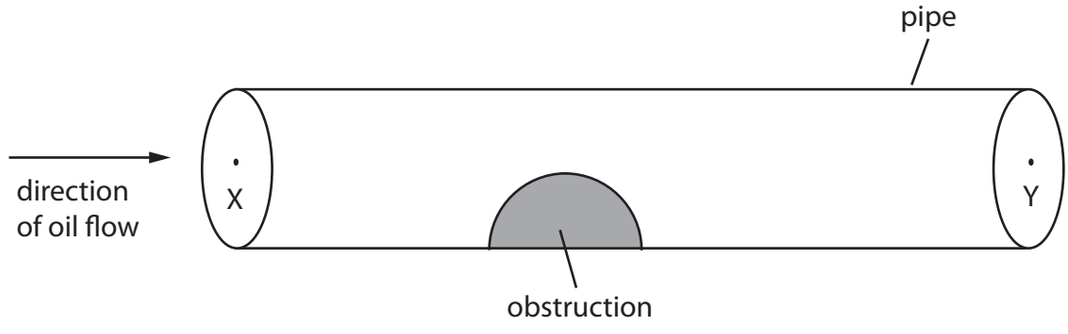
(b) The pipe becomes partially obstructed as shown in the diagram.

The flow of oil is normally streamline.

The obstruction causes the flow of oil to become turbulent.

Draw a fluid flow pattern for the oil from point X to point Y on the diagram.

(2)



(c) Explain how the velocity of the oil changes due to changes in the viscosity of the oil when the temperature rises.

(3)

.....

.....

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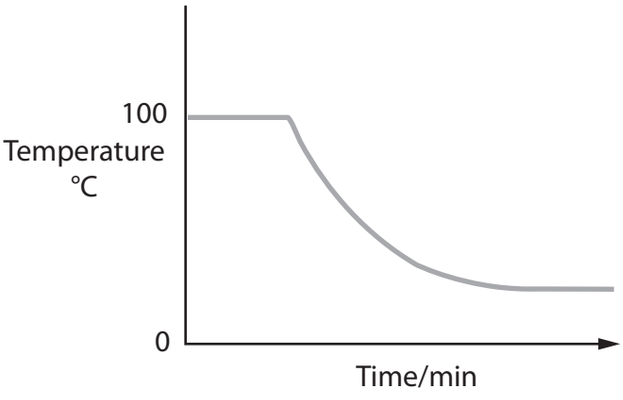
.....

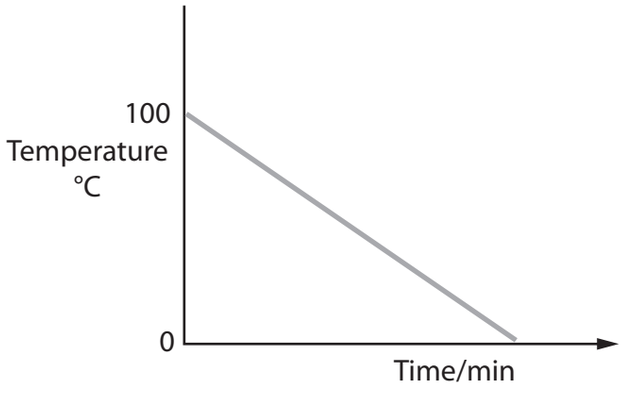
(Total for Question 11 = 6 marks)

12 (a) Steam at 100°C is cooled at a constant rate until it becomes ice.

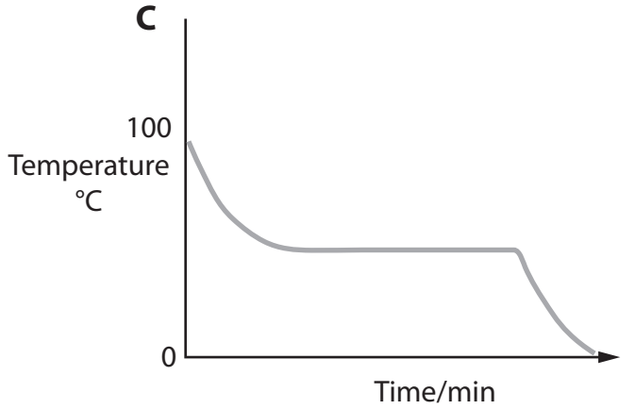
A



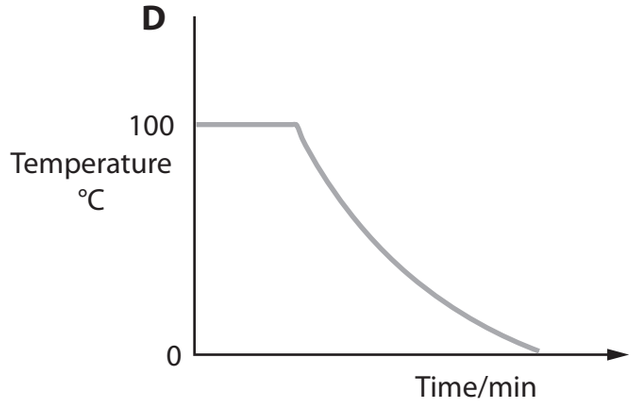
B



C



D



Identify which graph shows the correct changes in temperature.

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) A power station boiler produces some steam.

A power station uses steam to turn a turbine.

The steam is then condensed.

(i) The steam loses 5.65×10^9 J of thermal energy when it is condensed into water.

The specific latent heat of vaporisation of water is 2.26×10^6 J kg^{-1}.

Calculate the mass of steam converted into water by the cooling tower.

Show your working.

(3)

mass ..... kg

(ii) The power station has a maximum theoretical efficiency of 0.56.

The water leaving the power station cooling tower has a temperature of 298 K.

Calculate the temperature of the steam in the turbine.

Show your working.

(3)

temperature of steam = ... K

(c) Energy is required to heat water to its boiling point, 100 °C.

200 times more energy is needed to change the same amount of boiling water into steam at 100 °C.

Explain, in terms of the behaviour of water molecules, why there is a difference in the energy required for the two processes.

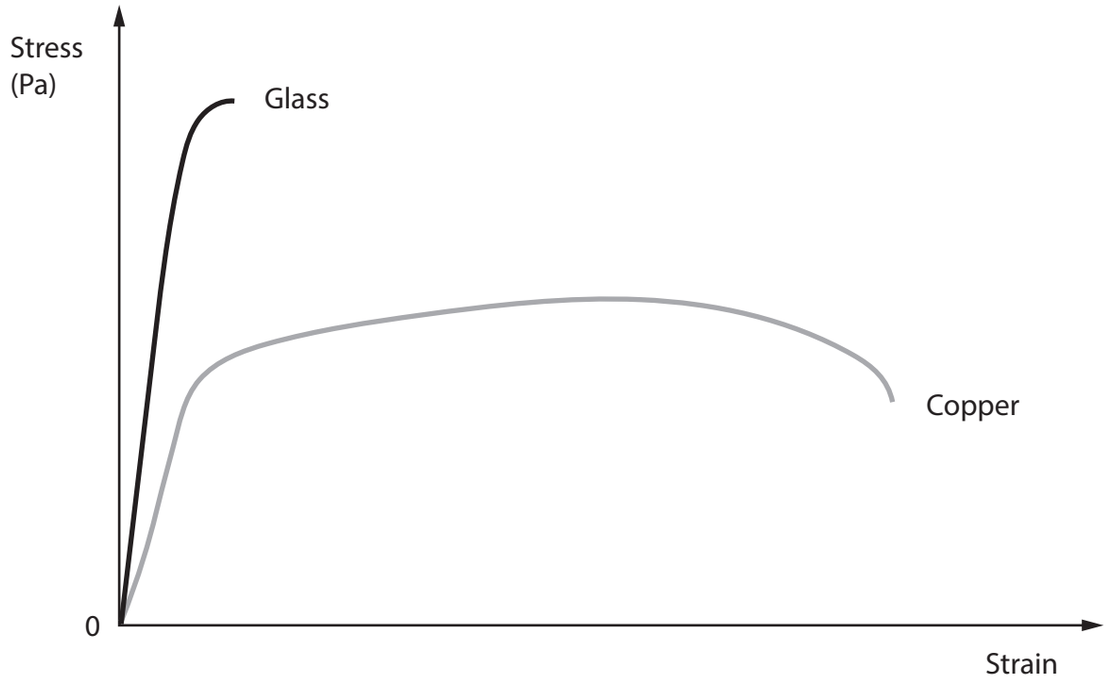
(4)

(Total for Question 12 = 11 marks)

13 Copper and glass are both used in the building industry.

Glass is a brittle material and copper is a ductile material.

The graph shows the stress – strain curves for glass and copper.



(a) (i) State how the graph shows that glass is stronger than copper.

(1)

.....

.....

(ii) Give a reason why, using the graph, copper is more ductile than glass.

(1)

.....

.....

(b) A steel wire is used to suspend a light fitting from a ceiling.

The tensile stress in the wire is 1×10^9 Pa.

The wire has a cross sectional area of 0.5 mm^2

Calculate the weight of the light fitting.

Show your working.

(4)

weight of light fitting = ... N

(c) Roofing lead is used as a building material.

Explain how creep can cause roofing lead to become damaged.

(4)

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(Total for Question 13 = 10 marks)

14 Mechanical and thermal systems can be controlled by an isothermal process.

(a) State what is meant by the term isothermal process.

(1)

.....

.....

(b) Give **two** reasons why a heat engine cannot be 100% efficient.

(2)

.....

.....

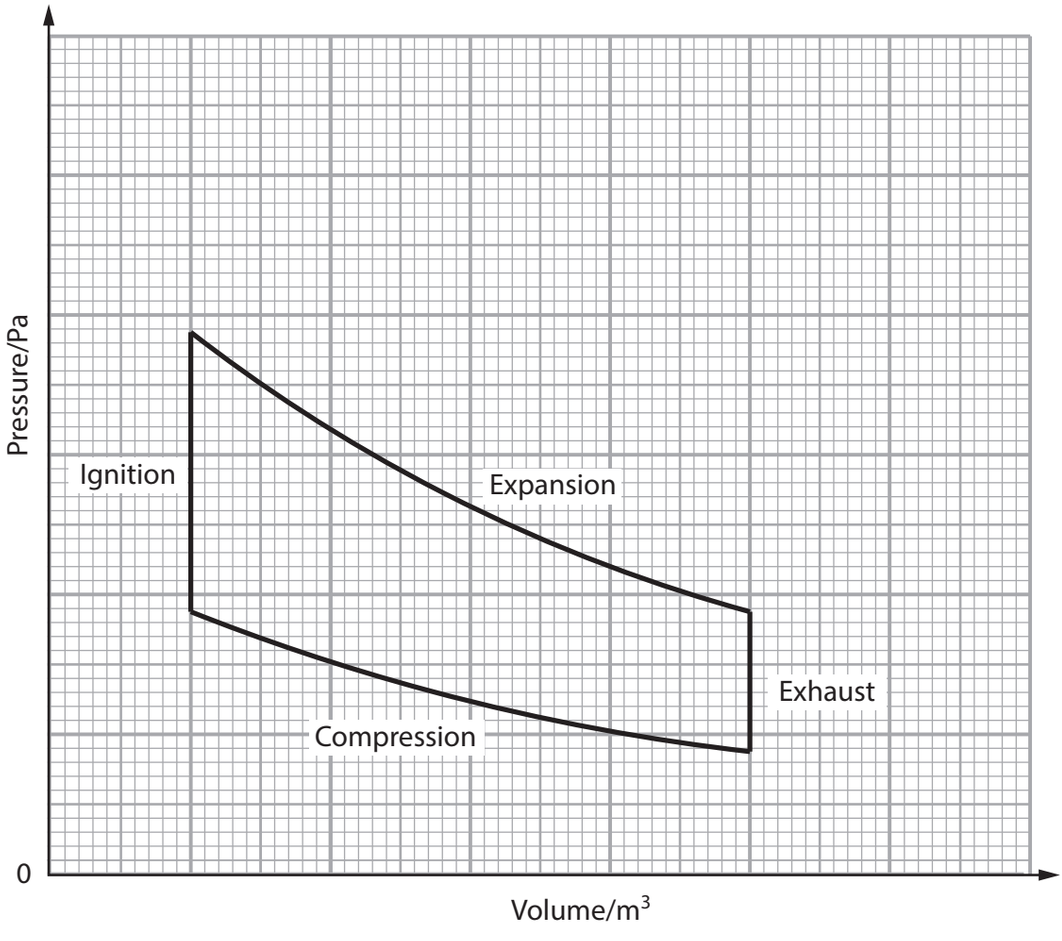
.....

.....

(c) A petrol engine is a heat engine.

A fuel and air mixture burn in the cylinders of a petrol engine to do work.

The graph shows how the pressure and volume of the gas in a cylinder changes during the heat engine cycle.



Explain how a petrol engine is a form of heat engine.

Use the graph to support your answer.

(6)

(Total for Question 14 = 9 marks)

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

Formulae Sheet

Mechanics

Work	$\Delta W = F\Delta x$
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	$\mathrm{pV = NkT}$
First law of thermodynamics	$\mathrm{\Delta Q = \Delta U + \Delta W}$
Specific heat capacity	$\mathrm{\Delta Q = mc\Delta T}$
Specific latent heat	$\mathrm{\Delta Q = \Delta mL}$

Materials

Density	$\rho = \frac{m}{V}$
Young modulus	$\text{stress} = \frac{\mathrm{F}}{\mathrm{A}}$ $\text{strain} = \frac{\Delta x}{x}$ $E = \frac{\text{stress}}{\text{strain}}$
Hooke's law	$\mathrm{F = k\Delta}x$
Work done in stretching/ compressing a wire/spring	$\Delta \mathrm{E_{el}} = \frac{1}{2}\mathrm{F\Delta}$ $\Delta \mathrm{E_{el}} = \frac{1}{2}k(\Delta x)^2$

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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

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