Cambridge International **AS Level**

Cambridge International Examinations
Cambridge International Advanced Subsidiary Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

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5226594516

PHYSICAL SCIENCE **8780/03**

Paper 3 Structured Questions **October/November 2016**

1 hour 30 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
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10	
11	
Total	

This document consists of **16** printed pages.

CAMBRIDGE International Examinations

Answer **all** the questions in the spaces provided.

Relevant data, formulae and the Periodic Table are provided in the Data Booklet.

1 The graph in Fig. 1.1 shows the velocity of a cyclist during part of a journey on a straight level track.

The combined mass of the cyclist and the bicycle is 72 kg.

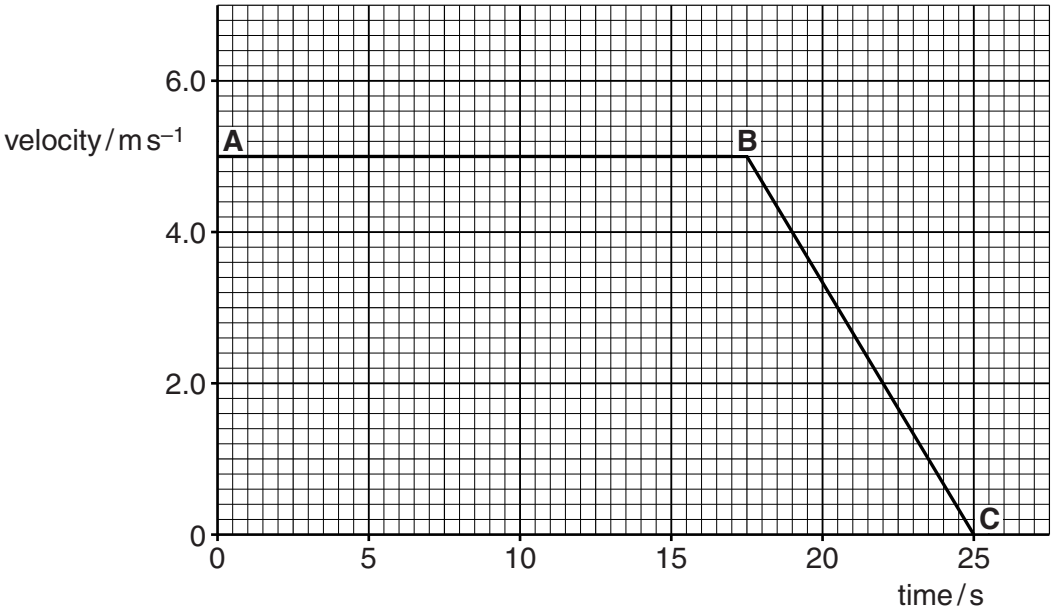


Fig. 1.1

(a) State the difference between speed and velocity.

.....

.....

..... [1]

(b) Deduce the resultant force on the bicycle during section **AB** of the journey.

force = ... N [1]

(c) **(i)** Calculate the resultant force on the bicycle during section **BC** of the journey.

force = ... N [2]

(ii) State the direction in which the resultant force acts in **(c)(i)**.

.....

..... [1]

[Total: 5]

2 The radioactive decay chain of $^{238}_{92}U$ consists of 8 alpha decays and 6 beta decays, to form a stable isotope.

(a) Identify the stable isotope.
Show your working.

stable isotope ..... [2]

(b) Explain why isotopes of the same element have the same chemical properties, but slightly different physical properties.

.....

.....

.....

.....

..... [4]

[Total: 6]

3 **(a)** Silicon is in Period 3 of the Periodic Table. It has a very high melting point.

(i) Explain, in terms of its structure and bonding, why the melting point of silicon is very high.

.....

.....

..... [2]

(ii) Table 3.1 shows the melting points of three other elements in Period 3.

Table 3.1

element	P	S	C*l*
melting point/K	317	392	172

Explain, in terms of their structure and bonding, the variation in melting points of P, S and C*l*.

.....

.....

.....

..... [3]

(b) A mixture of powdered sulfur and powdered zinc reacts to form zinc sulfide, ZnS. This reaction is exothermic.

(i) State what is meant by the term *exothermic*.

.....

..... [1]

(ii) The sulfur/zinc mixture needs to be heated before the reaction can start.

Explain why heating is needed to start many reactions that are exothermic.

.....

..... [1]

(iii) Complete the electronic configurations for a zinc atom and for a sulfide ion, S^{2-}.

zinc atom	Zn	$1s^2$
sulfide ion	S^{2-}	$1s^2$

[2]

(iv) Describe, in terms of electrons, how the reaction between sulfur and zinc occurs.

.....

.....

..... [2]

[Total: 11]

4 Fig. 4.1 shows a cylinder with a frictionless piston. The cylinder contains a gas.

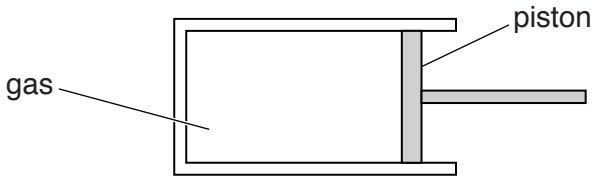


Fig. 4.1

(a) Explain why the gas exerts a pressure on the walls of the cylinder.

.....

.....

.....

.....

.....

.....

..... [4]

(b) The volume of the gas is reduced by slowly pushing the piston into the cylinder.

Explain why the pressure increases.

.....

.....

..... [2]

[Total: 6]

5 The sulfur impurity in crude oil can be removed by a process known as hydrotreating. In this process, crude oil fractions are mixed with hydrogen and heated to about 380 °C in the presence of a catalyst.

During this process, sulfur combines with hydrogen and is removed as hydrogen sulfide, H_2S.

The H_2S is converted into pure sulfur in a two-stage process.

The **overall equation** for this reaction is shown below.

$$4H_2S + 2O_2 \rightarrow 4S + 4H_2O$$

Stage 1 Some of the H_2S is reacted with oxygen as shown in the equation below.

$$2H_2S + 2O_2 \rightarrow S + SO_2 + 2H_2O$$

Stage 2 The SO_2 from Stage 1 reacts with the remaining H_2S to form two products.

(a) (i) Deduce an equation for the reaction occurring in Stage 2.

..... [1]

(ii) Explain, in terms of oxidation numbers, what happens to the sulfur in Stage 1.

.....

.....

.....

..... [2]

(iii) Use the **overall equation** to calculate the mass of H_2S required to produce 4.78 tonnes of elemental sulfur.

mass of H_2S = ... tonnes [2]

(iv) Calculate the volume, in m^3, occupied by 1.54×10^5 mol of H_2S at 380 °C and 5.00×10^5 Pa.

The gas constant, $R = 8.31 J K^{-1} mol^{-1}$.

volume of H_2S = ... m^3 [3]

(b) Water is a product of the hydrotreating process.

(i) Draw the shape of a water molecule, including all lone pairs of electrons.

[1]

(ii) State the H–O–H bond angle in a water molecule.

..... [1]

[Total: 10]

6 A microphone is connected to a cathode ray oscilloscope (c.r.o.). A loudspeaker produces a sound wave.

Fig. 6.1 shows the trace seen on the c.r.o.

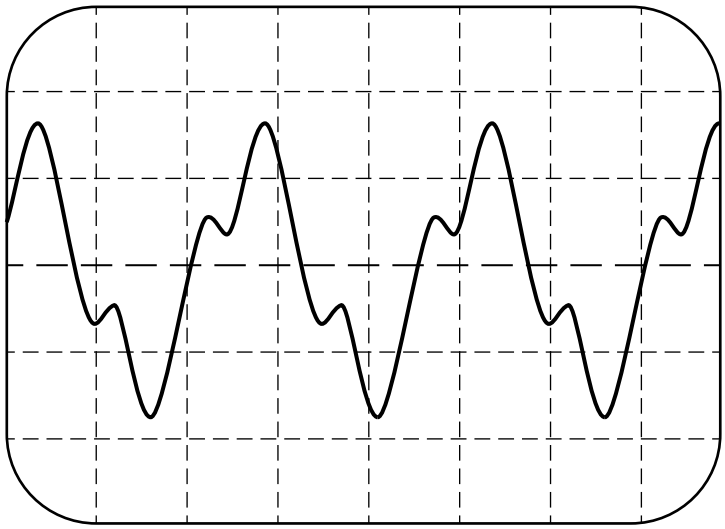


Fig. 6.1

(a) On Fig. 6.1, draw an arrow to identify the amplitude of the trace and label it **A**. [1]

(b) The time base of the c.r.o. is set at 800 μs per division.

Calculate the frequency of the sound wave.

frequency = ... Hz [2]

(c) The speed of sound in air is 320 m s^{-1}.

Calculate the wavelength of the sound wave.

wavelength = ... m [2]

[Total: 5]

7 Fig. 7.1 shows a ray diagram of an experiment to demonstrate superposition of microwaves. Some of the microwaves travel directly to point **P**. Some of the microwaves reflect off the metal plate.

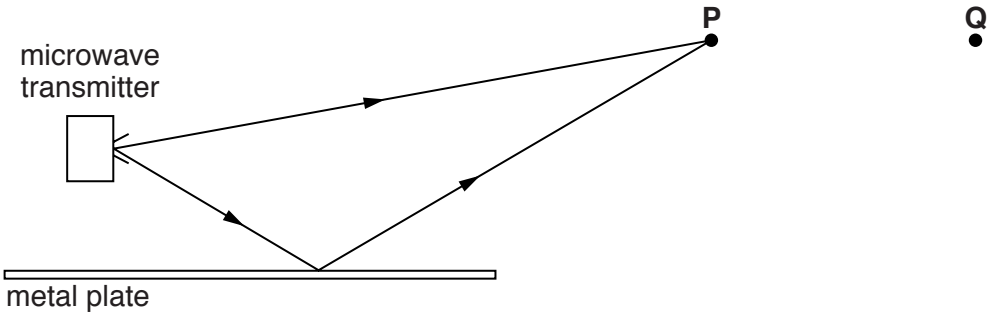


Fig. 7.1

(a) State what is meant by the term *superposition*.

.....

.....

..... [1]

(b) A microwave detector is placed at point **P** and moved slowly to point **Q**. An interference pattern of maximum and minimum signals is detected.

Explain how a maximum signal is formed.

.....

.....

.....

.....

..... [3]

(c) The microwave transmitter is adjusted to emit microwaves of shorter wavelength.

Describe and explain the effect this has on the interference pattern detected between **P** and **Q**.

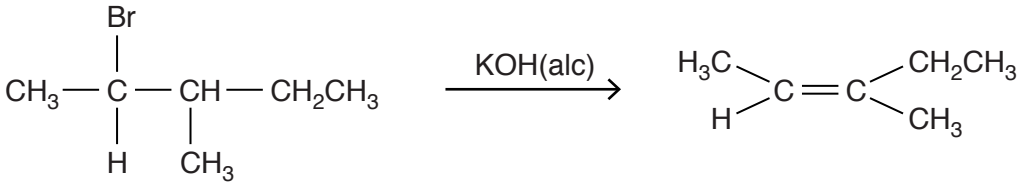
.....

.....

..... [2]

[Total: 6]

8 Compound **A** is heated with a solution of potassium hydroxide dissolved in ethanol. Compound **B** is one of the products formed.



compound **A** compound **B**

(a) **(i)** Name compound **A**.

..... [1]

(ii) State the type of reaction occurring in the formation of compound **B**.

..... [1]

(b) In this reaction, three organic products **B**, **C** and **D** are formed. All three compounds have the same molecular formula. All three of these isomers decolourise bromine water.

Draw displayed formulae for **C** and **D**.

compound **C** compound **D**

[2]

(c) Two different types of isomerism are displayed in the products **B**, **C** and **D**.

(i) Name one type of isomerism displayed in these products and identify a pair of compounds from **B**, **C** and **D** that displays this type of isomerism.

type of isomerism .....

pair of compounds .....
[1]

(ii) Name the other type of isomerism displayed in these products and identify a pair of compounds from **B**, **C** and **D** that displays this type of isomerism.

type of isomerism .....

pair of compounds .....
[1]

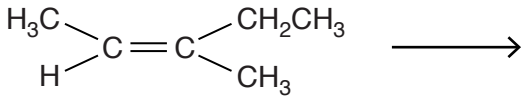
(d) Compound **B** can be converted back to compound **A** by reaction with hydrogen bromide, HBr. This addition reaction has an electrophilic mechanism.

(i) State what is meant by an *addition reaction*.

.....

..... [1]

(ii) Complete the diagram to show the electrophilic mechanism for this addition reaction. In your mechanism, use curly arrows to show the movement of electron pairs.



[3]

[Total: 10]

9 Fig. 9.1 shows a high voltage power supply of e.m.f. 500 V. It has an internal resistor of resistance 2 kΩ.

A student connects the two output terminals together with a low resistance wire. The wire has resistance 0.1 Ω.

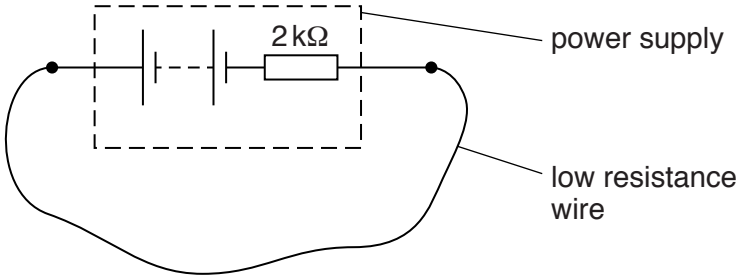


Fig. 9.1

(a) (i) Calculate the current in the low resistance wire.

current = ... A [1]

(ii) Describe how the internal resistor acts as a safety device.

.....

..... [1]

(b) The student disconnects the low resistance wire and connects the power supply into the circuit shown in Fig. 9.2. A high resistance voltmeter is connected as shown.

The negative temperature coefficient thermistor in the circuit has a resistance of 600 Ω at room temperature.

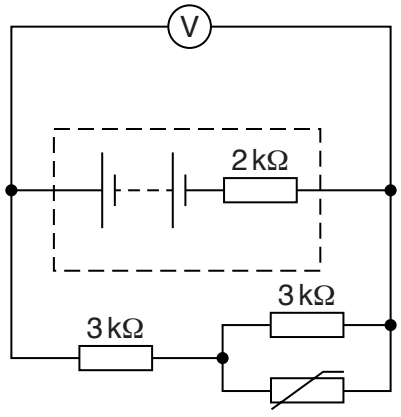


Fig. 9.2

(i) Calculate the reading on the voltmeter when the thermistor is at room temperature.

voltmeter reading = ... V [3]

(ii) The temperature of the thermistor increases.
State and explain the effect on the voltmeter reading.

.....

.....

..... [2]

[Total: 7]

10 Solid sodium chromate(VI), Na_2CrO_4, is yellow due to the presence of chromate(VI) ions, CrO_4^{2-}.

A sample of solid Na_2CrO_4 is dissolved in water. The CrO_4^{2-} ions in this solution undergo a reversible reaction to form orange dichromate(VI) ions, $Cr_2O_7^{2-}$.

The ionic equation for the reaction is shown below.

$$\underset{\text{yellow}}{2CrO_4^{2-}} + 2H^+ \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}} + H_2O$$

Eventually, in this solution, a dynamic equilibrium between CrO_4^{2-} and $Cr_2O_7^{2-}$ ions is created. This solution is yellow.

(a) (i) Describe what is meant by the term *dynamic equilibrium*.

.....

..... [2]

(ii) Suggest why the solution is yellow, rather than orange.

.....

..... [1]

(b) When dilute hydrochloric acid is added to the yellow solution, it turns orange.

(i) Explain, in terms of rate and equilibrium, why the solution turns orange.

.....

.....

.....

.....

..... [3]

(ii) An excess of dilute sodium hydroxide is added to the acidified solution.

Predict what you would observe and explain your answer in terms of the chemistry involved.

predicted observation .....

explanation .....

.....

..... [3]

[Total: 9]

11 Fig. 11.1 shows a small solid ball falling at its terminal velocity through a liquid. The ball is a sphere.

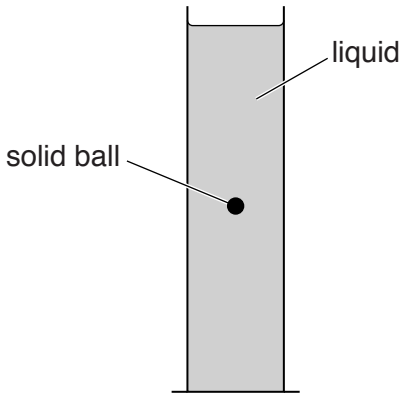


Fig. 11.1

(a) The viscosity of the liquid can be calculated using the formula shown.

$$\text{viscosity} = \frac{2r^2(\rho_s - \rho_l)g}{9v}$$

Table 11.1 identifies the symbols used in the formula.

Table 11.1

symbol	description	SI base unit
ρ_l	density of the liquid	.....
ρ_s	density of the solid (ball)	.....
g	acceleration due to gravity	.....
r	radius of the ball	m
v	the terminal velocity of the ball	.....

(i) Complete Table 11.1 to give the SI base unit of each of the quantities. One has already been done for you. [1]

(ii) Deduce the SI base unit of viscosity.

base unit ..... [1]

(b) To find the density of the ball the following measurements were taken.

diameter of ball = 2.82 ± 0.02 mm

mass of ball = 0.75 ± 0.01 g

(i) Calculate the percentage uncertainty in the measurement of the diameter of the ball.

uncertainty = ...% [1]

(ii) The volume V of a sphere is given by $V = \frac{4}{3}\pi r^3$.

Calculate the percentage uncertainty in the measurement of the density of the ball.

uncertainty = ...% [2]

[Total: 5]