Cambridge International AS Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8926933454

PHYSICAL SCIENCE **8780/03**

Paper 3 Structured Questions **October/November 2015**

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	
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4	
5	
6	
7	
8	
Total	

This document consists of **16** printed pages and **4** blank pages.

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

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

1 One of the early models of the atom was the Thomson 'plum-pudding' model.

(a) Give a brief description of this model of the atom.

....

....

....[1]

(b) Ernest Rutherford proposed an experiment to test the Thomson 'plum-pudding' model.

Describe this experiment.

In your description give

(i) an outline of the experiment,

....

....

....[2]

(ii) a summary of the results,

....

....

....[2]

(iii) a summary of Rutherford's conclusions.

....

....

....

....[3]

[Total: 8]

2 **(a)** Sodium, aluminium and sulfur are some of the elements in Period 3.

(i) Write equations to show the reactions of sodium oxide and sulfur trioxide with water.

....

....[2]

(ii) State how the acid/base behaviour of the oxides of the elements changes across Period 3.

....

....

....[1]

(iii) Suggest, in terms of electronegativity, an explanation for the variation in acid/base behaviour across Period 3.

....

....

....[1]

(iv) Aluminium oxide is amphoteric.

State what is meant by the term *amphoteric*.

....

....

....[1]

(b) Oxygen and sulfur are two elements in Group VI.

The boiling point of water, H_2O, is 373 K and that of hydrogen sulfide, H_2S, is 212 K.

(i) Name the strongest type of intermolecular force present in water.

....[1]

(ii) Name the strongest type of intermolecular force present in hydrogen sulfide.

....[1]

(iii) Use ideas from **(b)(i)** and **(b)(ii)** to explain why the boiling point of water is so much higher than that of hydrogen sulfide.

....

....

....[1]

[Total: 8]

3 Fig. 3.1 shows a source of sound of constant frequency. Sound travels directly to point **P** and is also reflected back from a wall to point **P**.

Fig. 3.1

(a) Fig. 3.2 shows a graph representing the wave that travels directly to point **P**.

Fig. 3.3 shows a graph representing the wave that is reflected from the wall to point **P**.

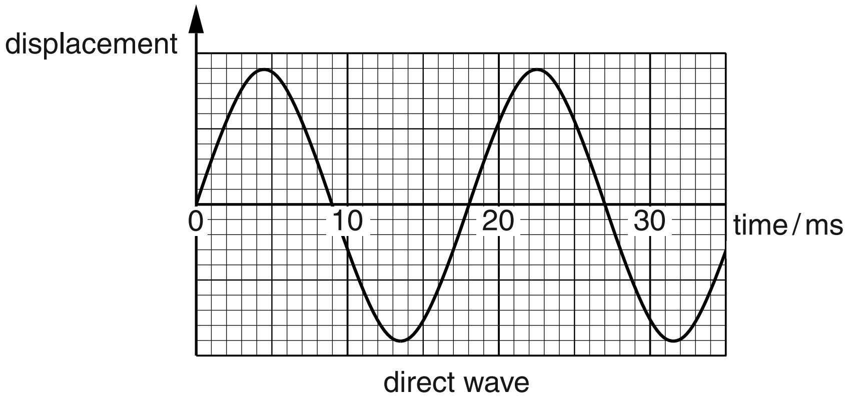


Fig. 3.2

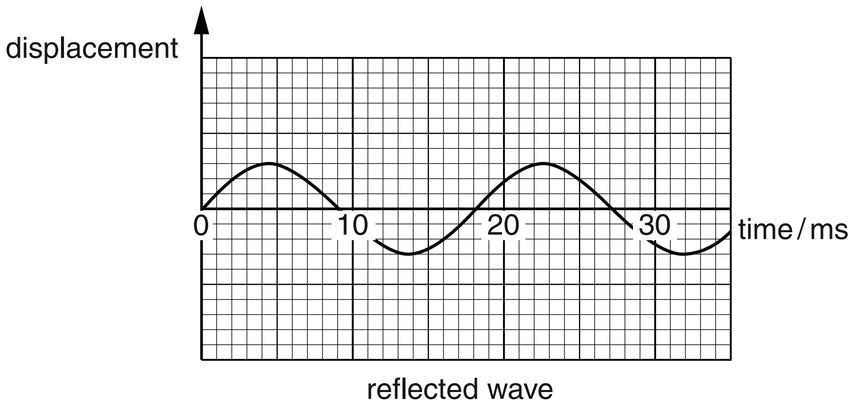


Fig. 3.3

(i) Determine the frequency of the waves.

frequency = ... Hz [2]

(ii) State the relationship between intensity and the amplitude of a wave.

....

....[1]

(iii) Determine the ratio of $\frac{\text{the intensity of the reflected wave}}{\text{the intensity of the direct wave}}$.

....[1]

(b) A student walks from the wall, directly to point **P**. He observes that the sound changes from loud to quiet and back to loud several times.

(i) Explain why the loudness of the sound varies in this way.

....

....

....

....[3]

(ii) Calculate the smallest distance between a point where the sound is loudest and a point where it is quietest.

(The speed of sound in air is $320\,\mathrm{m\,s^{-1}}$)

distance = ...[3]

(iii) Explain why the intensity is not zero at any point between the source and the wall.

....

....[1]

[Total: 11]

4 **(a)** Sodium carbonate, Na_2CO_3, is manufactured in a two-stage process as shown by the equations below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 800 g of sodium chloride.

[Relative formula mass, M_r: NaC*l*, 58.5; Na_2CO_3, 106]

maximum mass of sodium carbonate = ... g [3]

(b) Sodium carbonate neutralises hydrochloric acid as shown in the equation below.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

Washing soda is a hydrated form of sodium carbonate. Its formula is $Na_2CO_3.xH_2O$, where *x* represents the number of molecules of water of crystallisation.

A sample of washing soda of mass 0.643 g is dissolved in water.

The resulting solution is titrated against hydrochloric acid of concentration 0.175 mol dm^{-3}.

A total of 25.7 cm^3 of the hydrochloric acid is required for complete neutralisation.

(i) Calculate the amount, in moles, of HC*l* in 25.7 cm^3 of the hydrochloric acid.

amount of HC*l* = ... mol [1]

(ii) Deduce the amount, in moles, of sodium carbonate, Na_2CO_3, in the sample and hence determine the relative formula mass, M_r, of washing soda, $Na_2CO_3.xH_2O$.

amount of sodium carbonate = ... mol

$M_r(Na_2CO_3.xH_2O)$ = ...
[2]

(iii) Use your answer from **(b)(ii)** to calculate the number of molecules of water of crystallisation, x, present in washing soda.

x = ...[2]

[Total: 8]

5 Fig. 5.1 and Fig. 5.2 show an experiment designed to measure the speed of a bullet fired from a rifle. The bullet is fired towards a stationary wooden block which is suspended from a fixed point.

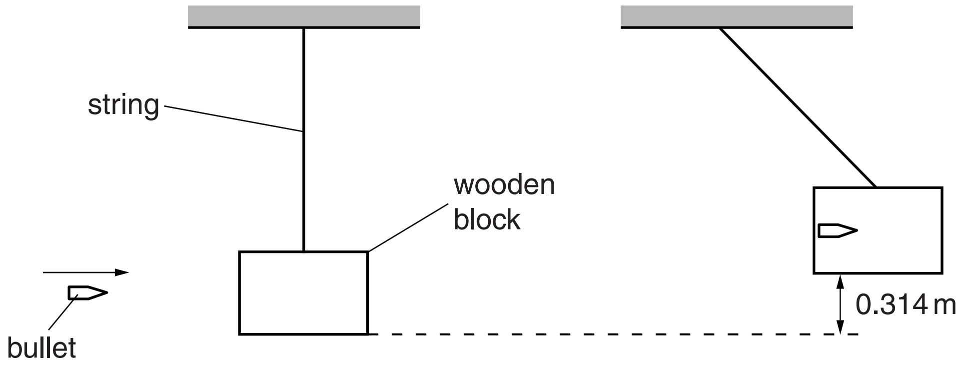


Fig. 5.1 **Fig. 5.2**

The bullet has a mass of 24.0 g.
The wooden block has a mass of 0.750 kg.

The bullet collides with and embeds in the wooden block.
The wooden block swings to the right, reaching a maximum height 0.314 m above the original height, as shown in Fig. 5.2.

Assume that

- the frictional forces on the moving wooden block are negligible,
- the bullet embeds instantaneously,
- the string does not stretch.

(a) (i) Calculate the gravitational potential energy gained by the wooden block with embedded bullet in Fig. 5.2.

gravitational potential energy gained = ... J [2]

(ii) Deduce the total kinetic energy of the wooden block with embedded bullet immediately after the collision.

kinetic energy = ... J [1]

(b) In a second experiment, using a different rifle, an identical bullet is fired at an identical wooden block. The total kinetic energy of the wooden block with embedded bullet is 2.80 J immediately after the collision.

(i) Calculate the speed of the wooden block with embedded bullet immediately after the collision.

speed .... $m\,s^{-1}$ [2]

(ii) Calculate the speed of the bullet just before the collision.

speed of the bullet .... $m\,s^{-1}$ [2]

(iii) Show by calculation whether or not the collision is elastic.

[3]

[Total: 10]

6 **(a)** Nitrogen is very unreactive, so the formation of nitrogen monoxide in air requires a very large amount of energy, such as is found during lightning strikes.

(i) Explain why nitrogen is very unreactive.

....

....[1]

(ii) Write an equation for the formation of nitrogen monoxide in air.

....[1]

(b) Nitrogen dioxide and carbon monoxide react together as shown in the equation below.

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g) \qquad \Delta H = -226\,kJ\,mol^{-1}$$

The activation energy, E_a, for this reaction is +132 kJ mol^{-1}.

An incomplete energy profile for this reaction is shown in Fig. 6.1.

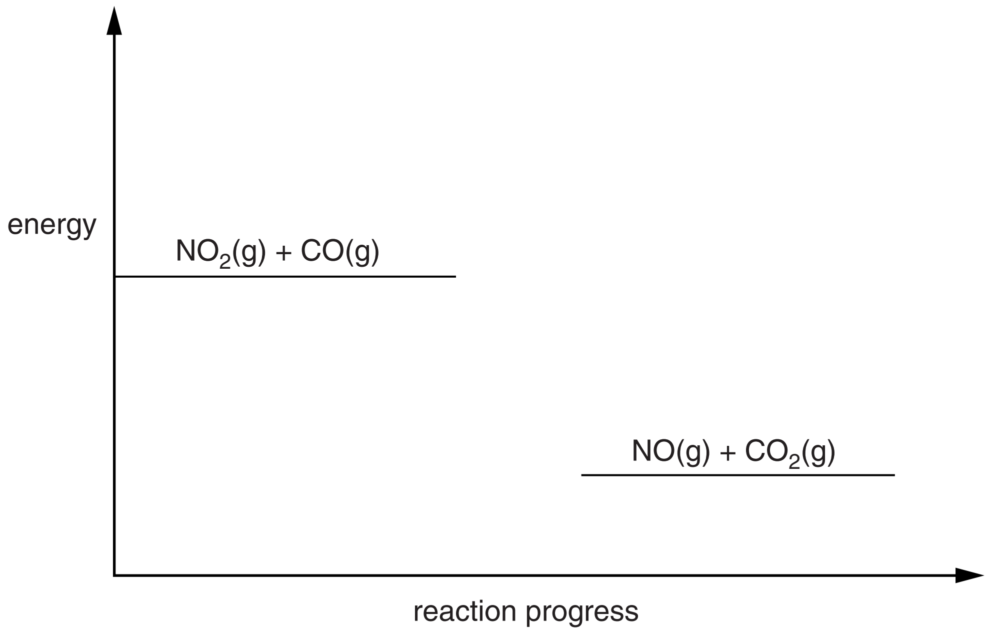


Fig. 6.1

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

....

....[1]

(ii) Complete Fig. 6.1 to show the energy profile for this reaction. Include labelled arrows to show the energy data given above. [3]

(iii) On Fig. 6.1, draw the energy profile for the reaction when a catalyst is used. Label this energy profile C. [1]

(c) The Maxwell-Boltzmann distribution in Fig. 6.2 represents the distribution of molecular energies in a gaseous reaction mixture.

On Fig. 6.2, the activation energy for this reaction is indicated by E_a.

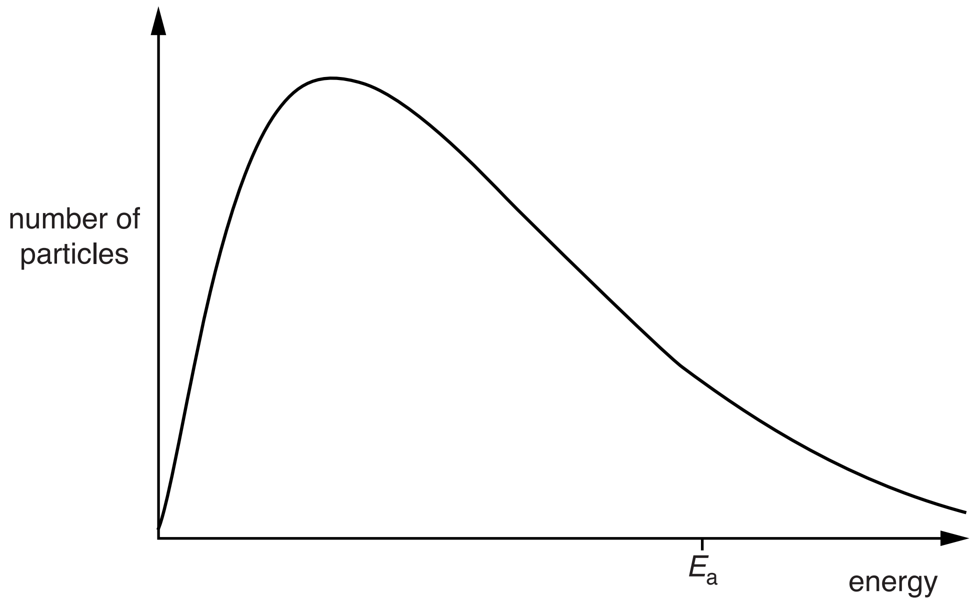


Fig. 6.2

(i) On Fig. 6.2, add 'E_a(cat)' to indicate the activation energy for this reaction when a catalyst is used. [1]

(ii) Explain, in terms of the Maxwell-Boltzmann distribution, why the use of a catalyst increases the rate of reaction.

....

....

....

....[2]

[Total: 10]

7 Fig. 7.1 shows a pair of parallel metal plates connected to a variable power supply. The plates are placed one above the other.

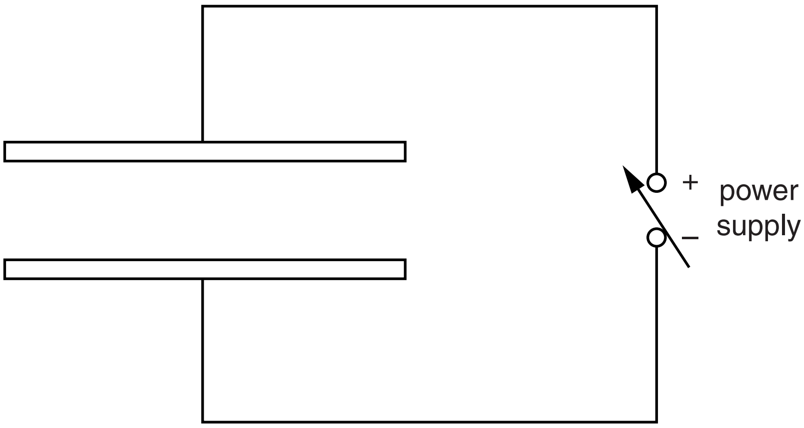


Fig. 7.1

(a) On Fig. 7.1, draw the electric field between the plates. [2]

(b) A very small droplet of oil carrying a small electric charge is introduced between the plates as shown in Fig. 7.2.

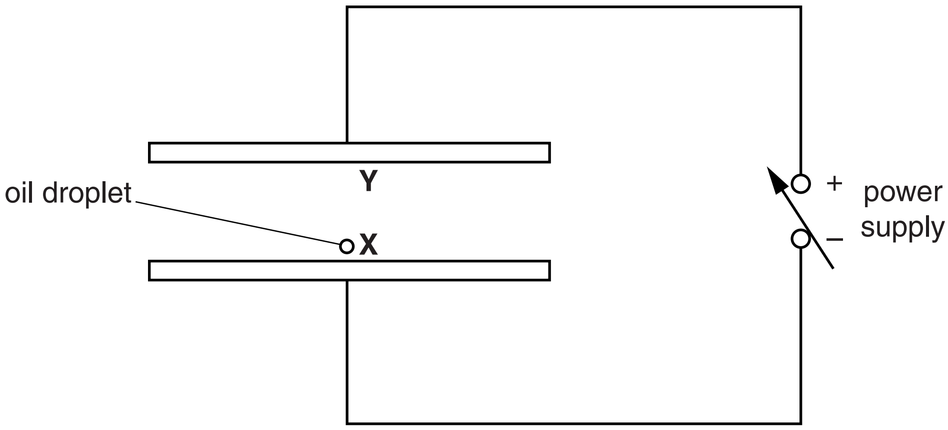


Fig. 7.2

The oil droplet moves up from point **X** to point **Y**.

(i) State the changes, if any, to the electric force on the oil droplet as it moves up.

....

....[1]

(ii) State the changes, if any, to the electric potential energy of the oil droplet as it moves up.

....

....[1]

(c) The potential difference across the plates in Fig. 7.2 is adjusted until the oil droplet comes to rest between the plates. The potential difference when this occurs is 1560 V.
The distance between the plates is 8.00 mm.

(i) Calculate the electric field strength.

electric field strength = ...[2]

(ii) The mass of the oil droplet is 9.21×10^{-14} kg.

Calculate the upward force needed to hold the droplet stationary. You may ignore the effect of any buoyancy forces.

upward force = ... N [1]

(iii) Calculate the charge on the oil droplet.

charge = ... C [2]

(iv) Calculate the number of extra electrons responsible for the charge on the oil droplet.

number of extra electrons .... [2]

[Total: 11]

8 Ethanoic acid is a weak acid and sulfuric acid is a strong acid.

(a) Explain, in terms of the Brønsted-Lowry theory, what is meant by the term *strong acid*.

....

....

....[2]

(b) Sulfuric acid is manufactured by the Contact process. One stage in this process is the conversion of sulfur dioxide into sulfur trioxide. The equation for this reaction is given below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

In this stage, a pressure of about 200 kPa (2 atm) is used.

(i) State the other **two** operating conditions used in this stage.

condition 1 ....

....

condition 2 ....

....

[2]

(ii) Explain, in terms of the Le Chatelier Principle, the effect of pressure on the yield of SO_3 in this reaction.

....

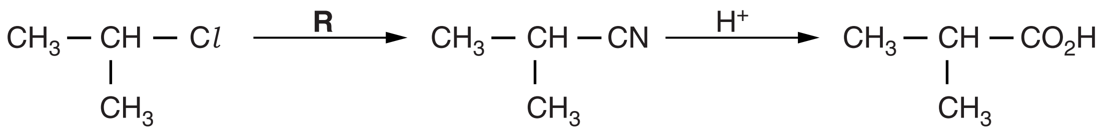
....

....

....

....[3]

(c) The weak acid, **Z**, can be prepared from the halogenoalkane, **X**, by the following reaction scheme.



compound **X** compound **Y** acid **Z**

(i) Write an equation to show acid **Z** behaving as a Brønsted-Lowry acid when dissolved in water.

....[1]

(ii) Identify by name, or by formula, a reagent **R** that could be used to convert compound **X** into compound **Y**.

....[1]

(iii) Give the systematic name of compound **Y**.

....[1]

(iv) Compound **Q** is a structural isomer of compound **Z**. The following observations are made.

Compound **Q**

1. does not react with sodium carbonate solution,
2. forms an orange solid when mixed with 2,4-dinitrophenylhydrazine, DNPH, but does not react with Tollens' reagent,
3. is oxidised to form an acid when heated with acidified potassium dichromate(VI).

Explain what the observations 1, 2 and 3 tell you about compound **Q**.

1. ....

....

2. ....

....

3. ....

....
[3]

(v) Use your answers in **(c)(iv)** to deduce a structural formula for compound **Q**.

....[1]

[Total: 14]

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