Cambridge International AS Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*8288531337*

**PHYSICAL SCIENCE** **8780/03**

Paper 3 Structured Questions **October/November 2014**

**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.

This document consists of **18** printed pages and **2** blank pages.

DC (CW/CGW) 83905/7


CAMBRIDGE International Examinations

**[Turn over**

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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** At room temperature, both sodium metal and sodium chloride are crystalline solids which contain ions.

**(a)** On Fig. 1.1, mark the charge on each ion in sodium metal and in sodium chloride.

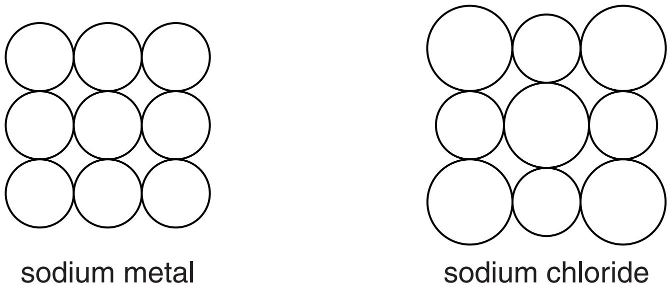


**Fig. 1.1**

[2]

**(b) (i)** Describe how the ions are held together in solid sodium metal.

..........................................................................................................................................

.....................................................................................................................................[1]

**(ii)** Describe how the ions are held together in solid sodium chloride.

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**(c) (i)** Explain why both molten and solid sodium metal conduct electricity.

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**(ii)** Explain why molten sodium chloride conducts electricity, but solid sodium chloride does not.

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.....................................................................................................................................[2]

[Total: 7]

**2** In this question you are to estimate the average rate of energy loss as an airliner descends from its cruising height, lands, and comes to rest on the runway.

The airliner starts to lose height 30 minutes before it comes to rest on the runway.

Table 2.1 shows the quantities and their estimated values needed in order to calculate the energy lost by the airliner.

**Table 2.1**

| quantity | estimated value |
|---|---|
| cruising height above the runway | 8000 m |
| mass of the loaded airliner | $3 \times 10^5$ kg |
| cruising speed | 200 m $s^{-1}$ |

**(a)** Use the values in Table 2.1 to estimate

**(i)** the total energy loss of the airliner,

total energy loss = ............................................... J [4]

**(ii)** the average rate of energy loss.

average rate of energy loss = ............................................... W [2]

**(b)** **(i)** The speed of the airliner as its wheels touch the runway is 250 km $h^{-1}$.

The average braking force of the airliner during landing is 400 kN.

Calculate the distance the airliner travels along the runway before it comes to rest.

distance = .............................................. m [3]

**(ii)** Suggest why the runway needs to be significantly longer than the distance calculated in **(b)(i)**.

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..........................................................................................................................................[1]

[Total: 10]

**3** Nitroglycerine, $C_3H_5N_3O_9$, is an explosive. On detonation, it decomposes rapidly to [illegible] number of gaseous molecules. The equation for this decomposition is given below.

$$4C_3H_5N_3O_9(l) \rightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$$

**(a)** State what is meant by the term *one mole* of molecules.

..........................................................................................................................................

..........................................................................................................................................[1]

**(b)** A sample of nitroglycerine was detonated and produced 0.350 g of oxygen gas.

**(i)** Show that the amount of oxygen gas produced is $1.09 \times 10^{-2}$ mol and hence deduce the total number of moles of gas formed in this reaction.

total number of moles of gas = ............................................... [2]

**(ii)** Calculate the number of moles, and the mass, of nitroglycerine detonated.

number of moles of nitroglycerine = ...............................................

mass of nitroglycerine = ............................................... g
[2]

**(c)** A second sample of nitroglycerine is placed in a strong, sealed container and de
The container does not break or change volume.

The volume of the container is $1.00 \times 10^{-3}\,m^3$.

The resulting decomposition produces a total of 0.873 mol of gaseous products at a temperature of 1100 K.

**(i)** State the ideal gas equation.

............................................................................................................................[1]

**(ii)** Use the ideal gas equation to calculate the pressure in the container after detonation. Give the unit for your answer.

(the gas constant, $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

pressure = ................................ unit ................... [3]

[Total: 9]

**4** Blood pressure is defined as the excess pressure in a person's arteries compared to pressure.

Fig. 4.1 and Fig. 4.2 show apparatus that can be used to measure blood pressure. The cu placed around the patient's arm and air is pumped into the tube in the cuff. This causes th mercury to be pushed around the U-tube. The valve, when closed, prevents air from coming back out of the cuff.

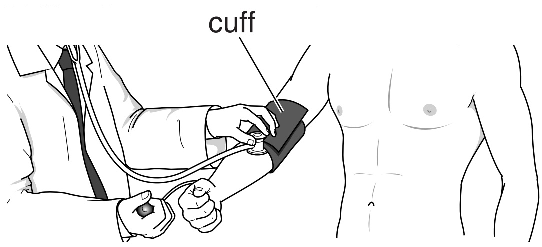


**Fig. 4.1**

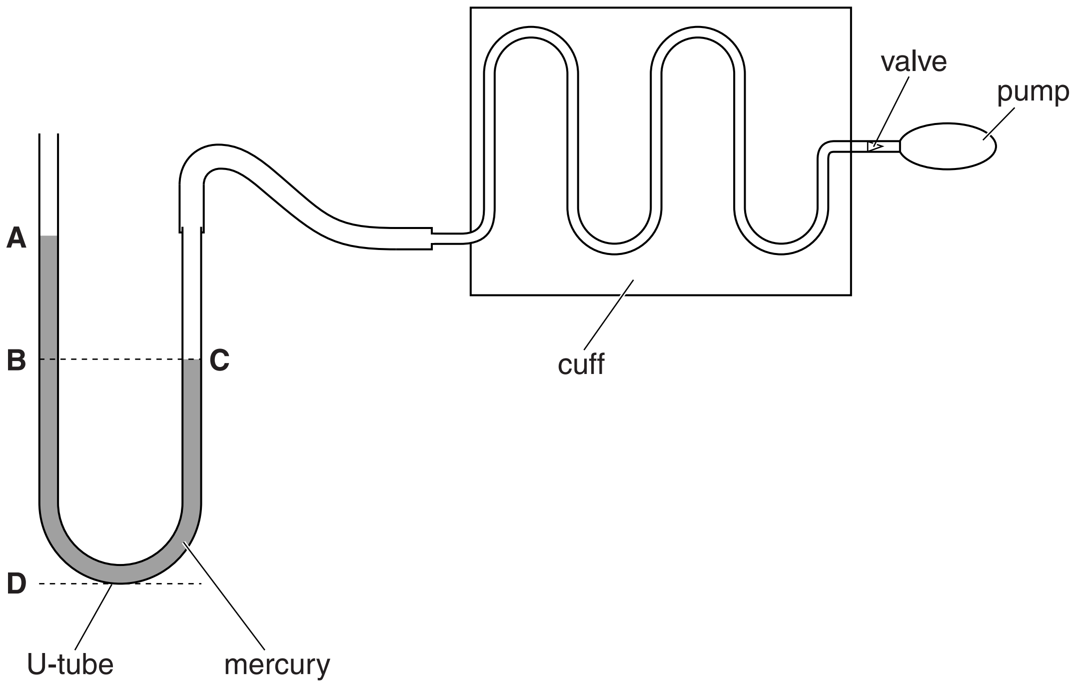


**Fig. 4.2**

**(a)** Explain, in terms of the kinetic molecular model,

**(i)** why the atmosphere exerts a pressure on the mercury at point **A**,

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**(ii)** why the pressure is greater at **C** than at **A**.

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.......................................................................................................................................[2]

**(b)** The air in the cuff is released slowly by opening the valve. The valve is closed again when the pressure at **C** is equal to the maximum pressure of the patient's blood.

For a particular patient, the distance **BD** is 280 mm and the distance **AD** is 395 mm.

The density of mercury is 13 600 kg $m^{-3}$.

Calculate the blood pressure of the patient in pascal.

pressure = ............................................... Pa [2]

[Total: 7]

**5** Fig. 5.1 shows an experiment designed to demonstrate interference of visible light. In … e is a single slit. In card **B** there are two slits, separated by distance *x*.

A series of bright and dark fringes is observed on the screen.

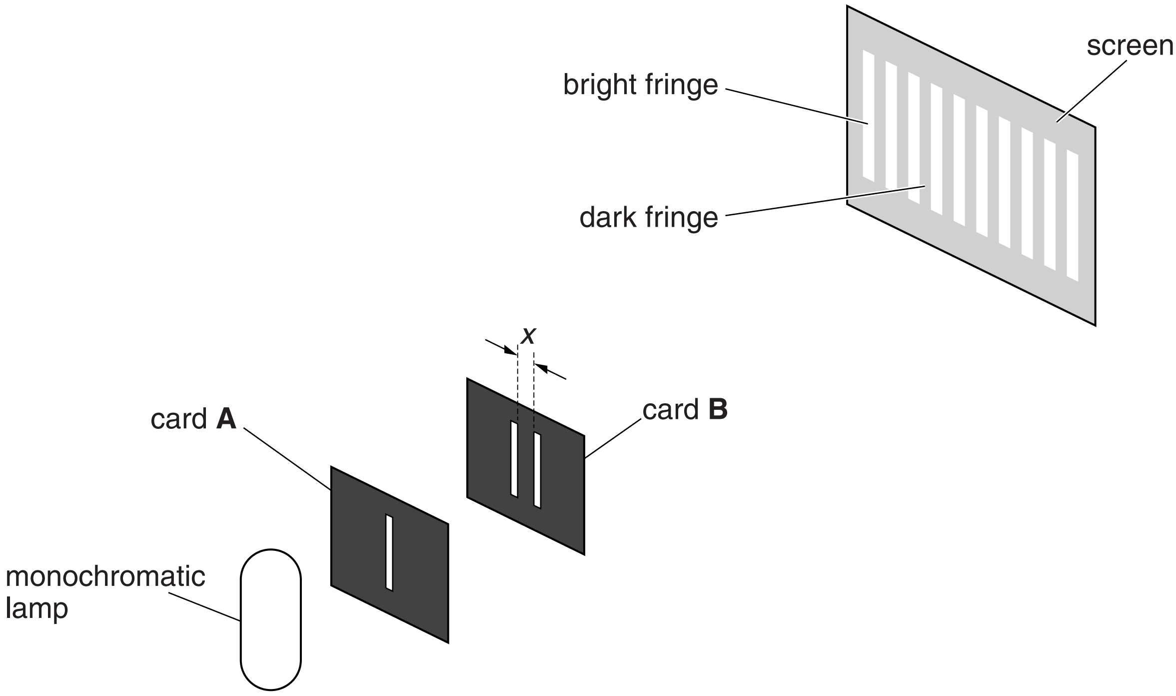


**Fig. 5.1**

**(a)** Explain why the single slit in card **A** must be narrow.

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**(b)** State the effect of using a different card **B** which has

**(i)** a smaller distance *x* between the slits,

.....................................................................................................................................[1]

**(ii)** narrower slits.

.....................................................................................................................................[1]

**(c)** **(i)** State what is meant by *monochromatic light*.

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.......................................................................................................................................[

**(ii)** In the experiment shown in Fig. 5.1, white light is used instead of monochromatic light.

Predict what would be observed on the screen and give a reason for your answer.

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...........................................................................................................................................

...........................................................................................................................................

.......................................................................................................................................[2]

[Total: 7]

**6** The dimerisation of nitrogen dioxide, $NO_2$, to form dinitrogen tetroxide, $N_2O_4$, is exoth

This reaction is reversible as shown in the equation below.

$$\underset{\text{brown gas}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless gas}}{N_2O_4(g)}$$

In a sealed container, a dynamic equilibrium mixture of the two gases will eventually form.

**(a)** Explain what is meant by the term *dynamic equilibrium* as applied to a chemical reaction.

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.....................................................................................................................................[2]

**(b)** A teacher prepared three sealed glass containers, **A**, **B** and **C**, each filled with nitrogen dioxide. The containers were left at a temperature of 35 °C until the contents reached equilibrium. After some time, the contents of each container were light brown in colour.

**(i)** The teacher then heated container **A** to 45 °C and cooled container **B** to 25 °C. Container **C** was kept at 35 °C.

Suggest how, if at all, the appearance of the contents of **A** and **B** would change relative to that of the contents of **C**.

Explain your answers.

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.....................................................................................................................................[3]

**(ii)** Explain why the contents of **A** take less time to reach equilibrium than the contents of **B**.

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.....................................................................................................................................[3]

**(c)** **(i)** Table 6.1 gives some values for enthalpy change of formation $\Delta H_f$.

**Table 6.1**

| compound | $\Delta H_f$ /kJ mol$^{-1}$ |
|---|---|
| $NO_2(g)$ | 33.18 |
| $N_2O_4(g)$ | 9.16 |

Use the data in Table 6.1 to calculate the enthalpy change for the dimerisation of $NO_2$.

enthalpy change = ............................................... kJ mol$^{-1}$ [1]

**(ii)** Write an equation for the reaction whose enthalpy change is the enthalpy change of formation of nitrogen dioxide.
Include state symbols.

.............................................................................................................................[1]

**(d)** In the laboratory, nitrogen dioxide can be produced by strongly heating solid magnesium nitrate, $Mg(NO_3)_2$. Write an equation for this reaction.

.............................................................................................................................[2]

[Total: 12]

**7** In the apparatus shown in Fig. 7.1, the cathode and anode are connected to a power d with a safety resistor. Electrons are emitted from the hot cathode and are accelerated to anode.

The ammeter reads 24 μA.

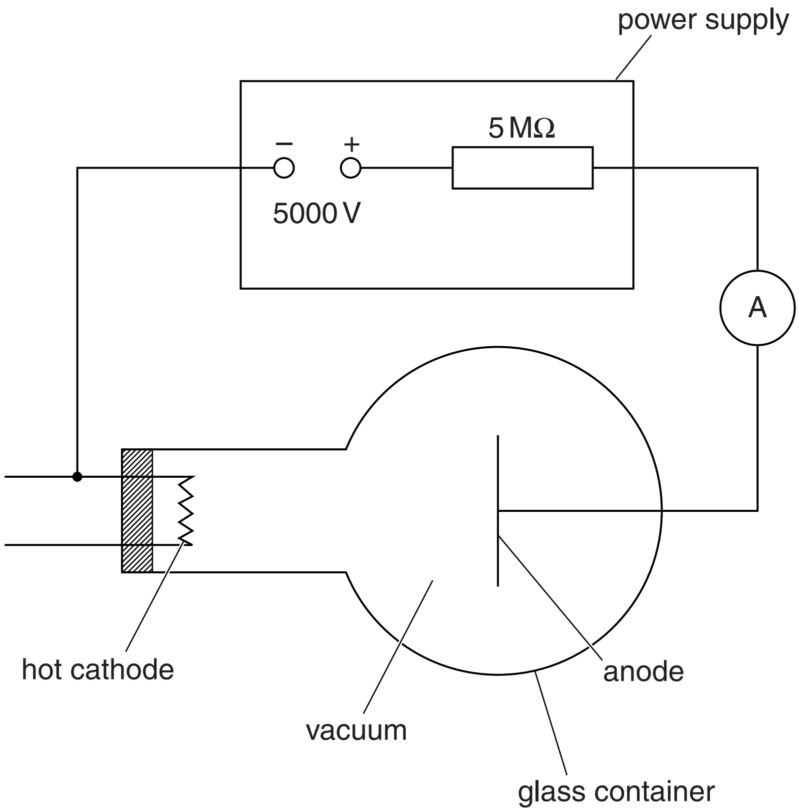



**Fig. 7.1**

**(a)** Calculate the total resistance in the circuit.

total resistance = ............................................... Ω [2]

**(b)** **(i)** Calculate the power dissipated in the safety resistor.

power = ............................................... W [1]

**(ii)** Calculate the output power from the power supply and hence the power diss... the glass container.

power dissipated inside the glass container = ................................................ W [2]

**(c)** **(i)** Deduce the charge hitting the anode each second and give the unit.

charge = .............................................. unit ....................................... [2]

**(ii)** Calculate the number of electrons hitting the anode each second. (electronic charge = $1.6 \times 10^{-19}$ C)

number of electrons = ................................................ [1]

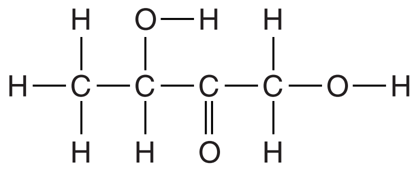
**(iii)** Use your answers to **(b)(ii)** and **(c)(ii)** to calculate the energy received by each electron as it moves from the cathode to the anode.

energy = .................................................................. J [1]

[Total: 9]

**8** The structural and displayed formulae of compound **P** are shown below.

$CH_3CH(OH)COCH_2OH$



Some reactions of compound **P** are shown in Fig. 8.1.

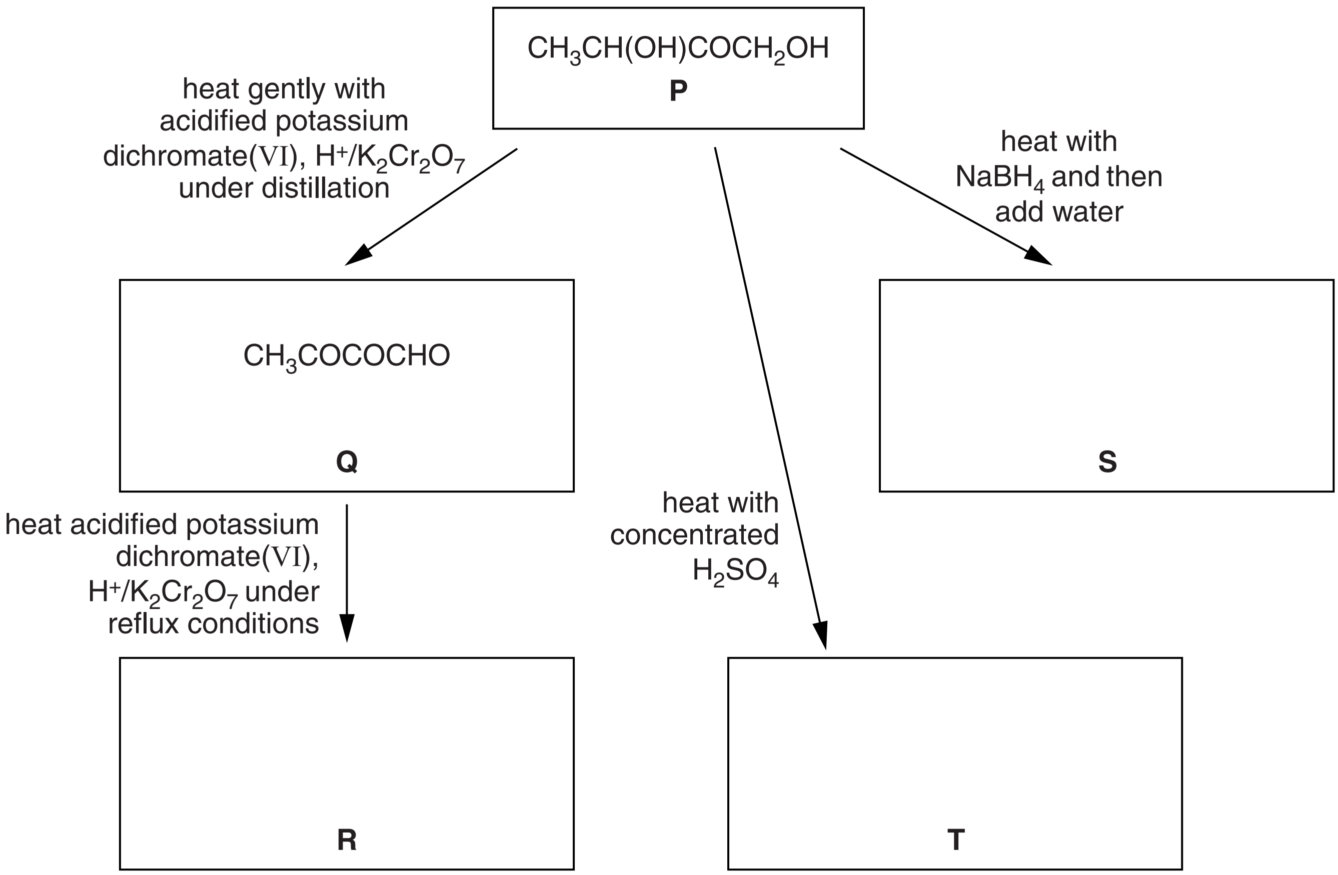



**Fig. 8.1**

**(a)** Name the type of reaction involved in the following conversions.

**P** into **Q** ..............................................................................

**P** into **T** ..............................................................................

[2]

**(b)** Compound **T** has the following composition by mass: C, 55.81 %; H, 6.98 %; O, 3

Calculate the empirical formula of **T**.

empirical formula of **T** = ............................................... [2]

**(c)** **(i)** In the appropriate boxes in Fig. 8.1, draw the structural formulae for the organic compounds **R**, **S** and **T**. [3]

**(ii)** In the space below, draw the **displayed** formula of compound **Q**.

[1]

**(d)** Consider the functional groups present in **P** and **Q**.

**(i)** State a test that would allow you to distinguish between pure samples of these two compounds. Describe the observations you would make if your chosen test is performed on **P** and on **Q**.

test ..........................................................................................................................

observation with **P** ..........................................................................................................

..........................................................................................................................

observation with **Q** ..........................................................................................................

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[3]

**(ii)** State the functional group identified by your test.

..........................................................................................................................[1]

[Total: 12]

**9** **(a)** **(i)** State Kirchhoff's second law.

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..........................................................................................................................................[1]

**(ii)** Explain the relationship between Kirchhoff's second law and the principle of conservation of energy.

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..........................................................................................................................................[1]

**(b)** Two cells are connected to a network of resistors as shown in Fig. 9.1. The cells and ammeter have negligible resistance.

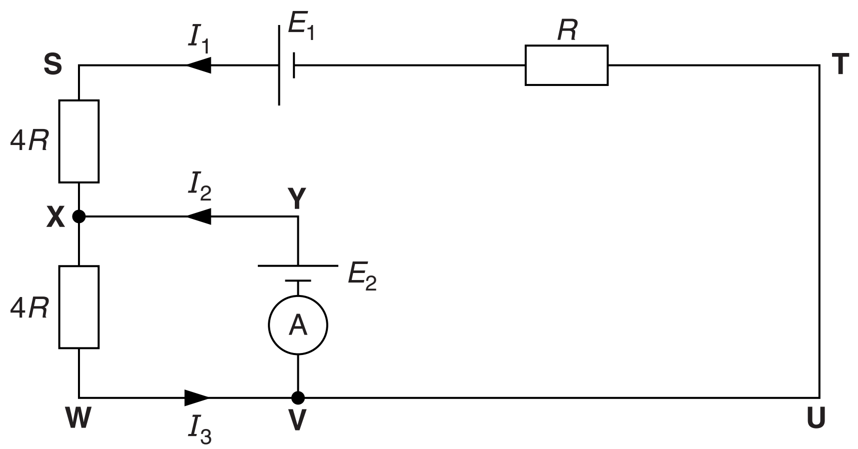


**Fig. 9.1**

**(i)** Use Kirchhoff's first law to deduce the relationship between $I_1$, $I_2$ and $I_3$.

[1]

**(ii)** Use Kirchhoff's second law for loop **XWVY** to deduce the relationship between $E_2$, $I_3$ and $R$.

[1]

**(iii)** Use Kirchhoff's second law for loop **SWUT** to express $E_1$ in terms of $R$, $I_1$ a

[1]

**(iv)** For a particular pair of cells, $E_1$ and $E_2$, the ammeter shows a zero reading.

Show that the ratio $E_2 : E_1 = 4 : 9$.

[2]

[Total: 7]

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