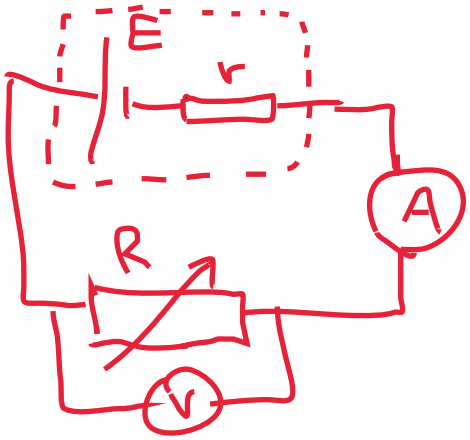
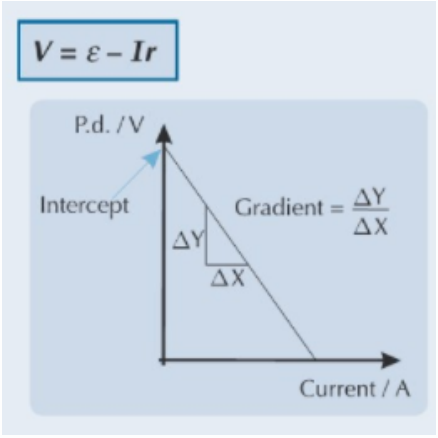
Q3

(b) Explain how you would determine experimentally the e.m.f. *E* and internal resistance *r* of the charged cell. Include a circuit diagram with meters and a variable load resistor.

In your answer you should state how the data collected is used to determine the values of E and r.





Take readings of V and I as you vary R

Plot V(y) vs I(x)

Compare with y=mx+c

y intercept = E and -grad (remember grad will be -) is the internal resistance

[5]

(c) A 6.0V 2.0W filament lamp has a resistance of 18Ω when lit to normal brightness. It is connected in series to four 1.5V cells each of internal resistance 0.90Ω.

(i) Explain, using calculations, why the lamp does not light to normal brightness.

total V = 1.5×4 = 6V

Total R = (0.9×4) + 18

= 21.6Ω

∴ I = 6/21.6 = 0.28A

So needs 0.3A but only 0.28 available

Bulb needs 2W at 6V ⇒ I = P/V = 2/6 = 0.3A

[3]

(ii) It is found that by adding more cells in series it is possible to make the lamp light to normal brightness. Calculate the total number of cells needed in the circuit for this to occur. Show your working clearly.

bulb needs terminal p.d = 6V, I = 0.33

each cell will provide V = ε − Ir

= 1.5 − 0.33×0.1

= 1.2V

number of cells = ... **[2]**

∴ need 5

34 A solar panel is charging a rechargeable battery, with a resistor R in series.

The values of the internal resistances r, the external resistance R and the e.m.f.s ε at the start of the charging process are shown in **Fig. 34**.

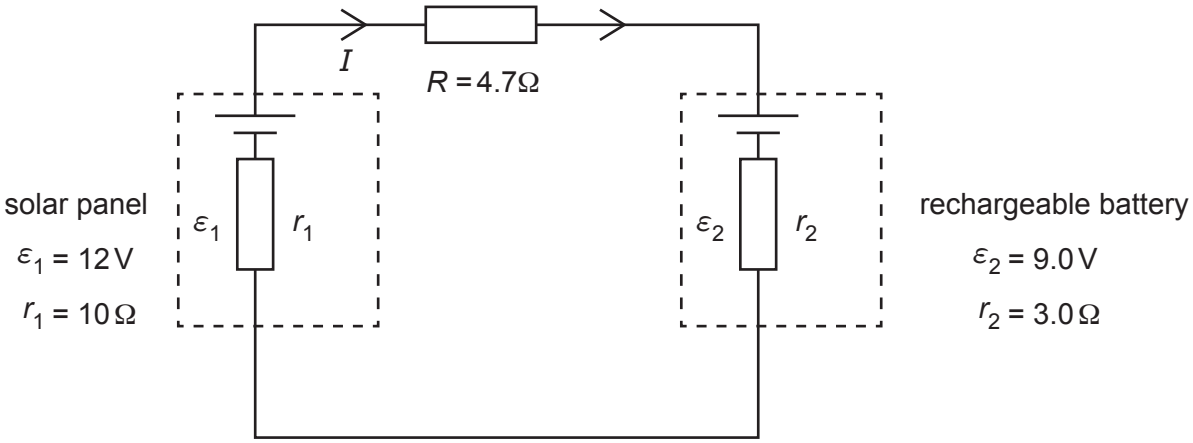


Fig. 34

(a) Show that the initial current charging the rechargeable battery I is less than 0.2 A.

$\frac{V}{R} = I = \frac{12-9}{10+4.7+3} = 0.17\,A$

[2]

(b) When fully charged, the rechargeable battery has enough charge to deliver an average current of 500 mA for an hour before it is fully discharged.

Estimate the time needed to recharge the battery at the mean charging current of 0.12 A.

$Q = 0.5 \times 60 \times 60 = 1800\,C$

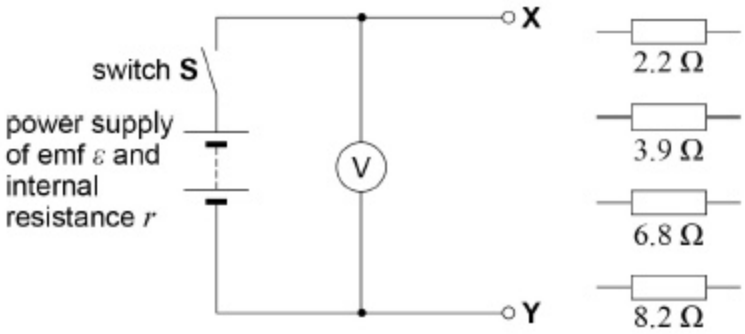
$Q = It \Rightarrow \frac{1800}{0.12} = 15{,}000\,s$

time = 4.16 / 4.2 hours **[2]**

7 This question is about an experiment to determine the internal resistance of a power supply.

A student is given the circuit and the four resistors of known resistance shown in **Figure 1**.

Figure 1



The student can change the external resistance R of the circuit between terminals **X** and **Y**. This is done by connecting different combinations of **two** resistors in series or in parallel between **X** and **Y**.

This method can produce **12 different values** for R.

(a) Calculate the largest value of R that the student can obtain using **two** resistors.

largest value of R = _____ Ω

(1)

(b) Calculate the smallest value of R that the student can obtain using **two** resistors.

smallest value of R = _____ Ω

(2)

(c) With switch **S** closed (in the on position) and no resistors connected between **X** and **Y** the voltmeter reading V is 1.62 V.

The student concludes that this voltmeter reading equals the emf ε of the power supply.

State why the student's conclusion that ε = 1.62 V was correct.

_____

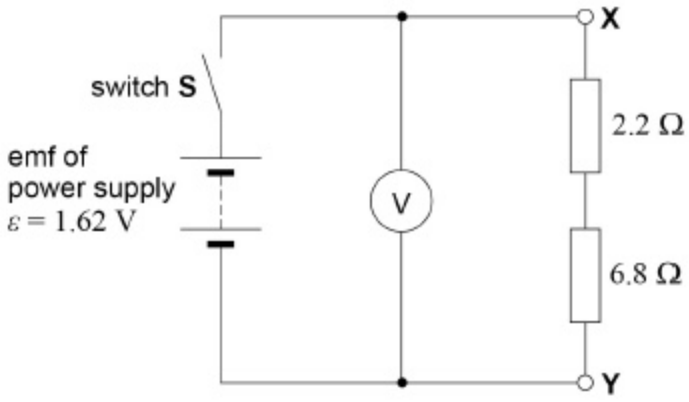
_____

_____

(1)

(d) **Figure 2** shows one particular combination and arrangement of two resistors that the student could use.

Figure 2



When **S** is closed the voltmeter reading V is 1.14 V.

Explain why V is less than 1.62 V when **S** is closed.

_____

_____

_____

(1)

(e) It can be shown that

$$\varepsilon - V = r \times \frac{V}{R}$$

where r is the internal resistance of the power supply.

Determine $(\varepsilon - V)$ and $\frac{V}{R}$ for this circuit using the data given in part (d).

$(\varepsilon - V)$ = _____ V

$\frac{V}{R}$ = _____ V Ω^{-1}

(1)

(f) The student obtains values of V for five further different values of R.

These data were used to produce the graph of ($\varepsilon - V$) against $\frac{V}{R}$ in **Figure 3**.

Plot the point you determined in part (e) on **Figure 3** and add a suitable best-fit line.

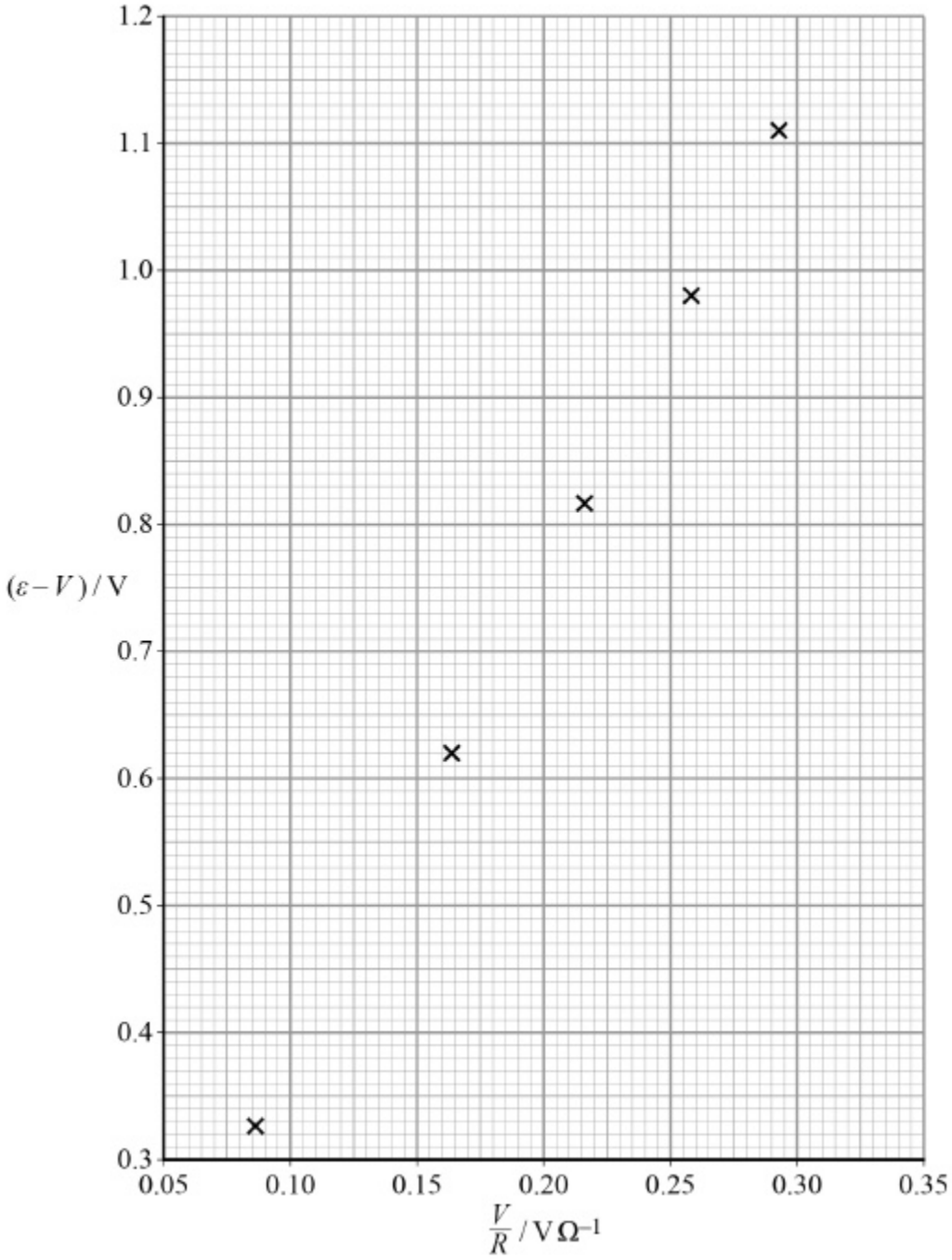
(1)

(g) Use **Figure 3** to determine *r*.

r = _____ Ω

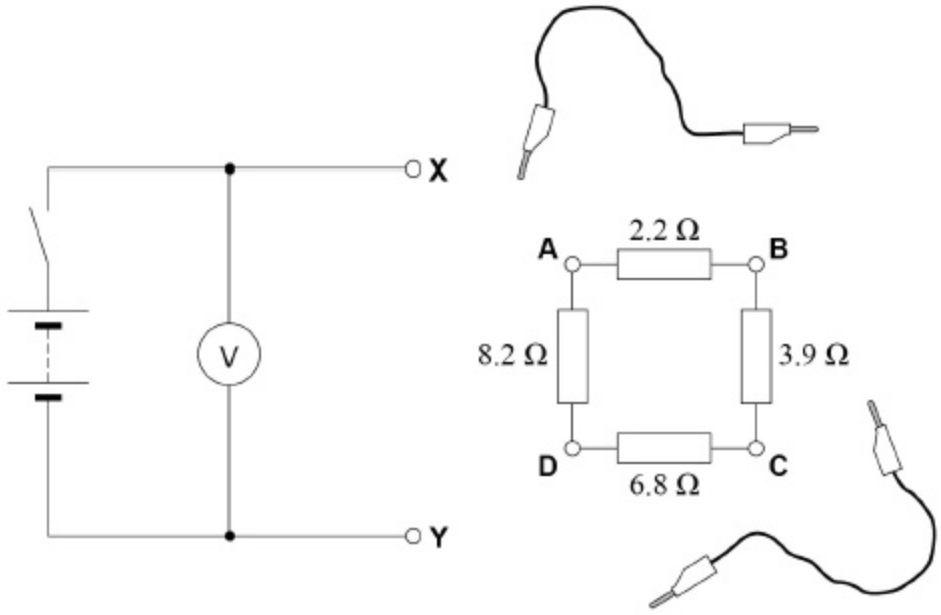
(2)

Figure 3


1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
$(\varepsilon - V)$ / V
0.05
0.10
0.15
0.20
0.25
0.30
0.35
$\frac{V}{R}$ / V Ω^{-1}

(h) **Figure 4** shows a different method for varying the resistance R described in part (a).

Figure 4



The four resistors are connected in a loop with sockets **A**, **B**, **C** and **D** at each junction. Two leads are used to connect the resistor loop to **X** and **Y**.

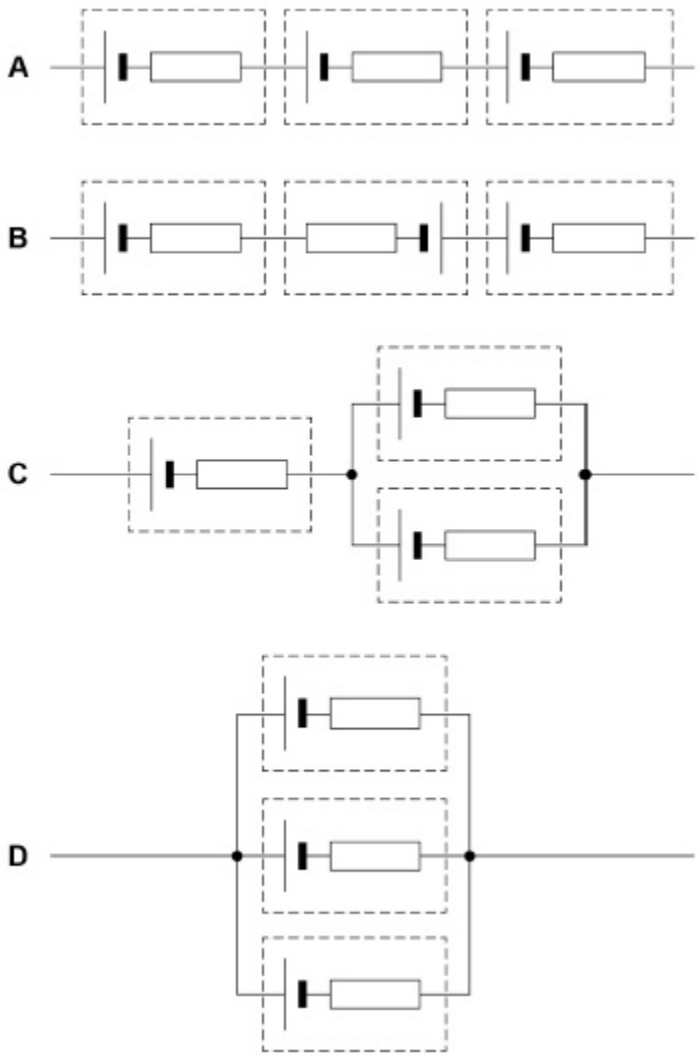
Discuss whether this method is an improvement over the method described in part (a). In your answer, you should refer to the number of different values that can be obtained for R.

(2)

(Total 11 marks)

8 Three cells each have an emf ε = 1.5 V and an internal resistance r = 0.6 Ω.

Which combination of these cells will deliver a total emf of 1.5 V and a maximum current of 7.5 A?



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)