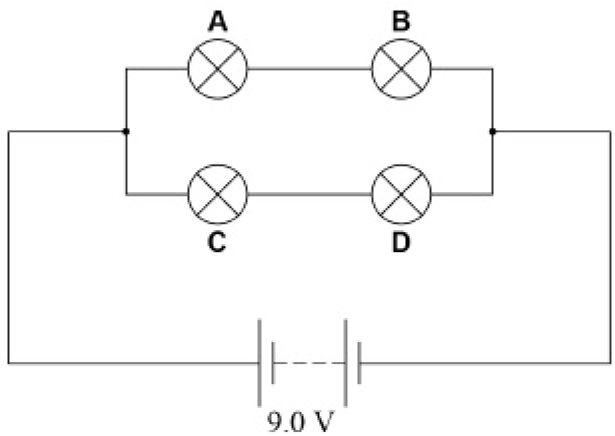
1 A student connects four lamps **A**, **B**, **C** and **D** in the circuit shown in **Figure 1**.
The battery has an emf of 9.0 V and negligible internal resistance.

Figure 1



(a) The table shows the operating conditions for the lamps when they are at normal brightness.

Lamps	Operating voltage / V	Power / W
A and **C**	6.0	6.0
B and **D**	3.5	4.1

The student observes that **two** of the lamps are at their normal brightness.
Assume that any changes in resistance of the lamps are negligible.

Determine which **two** lamps are at their normal brightness.

Use calculations to support your answer.

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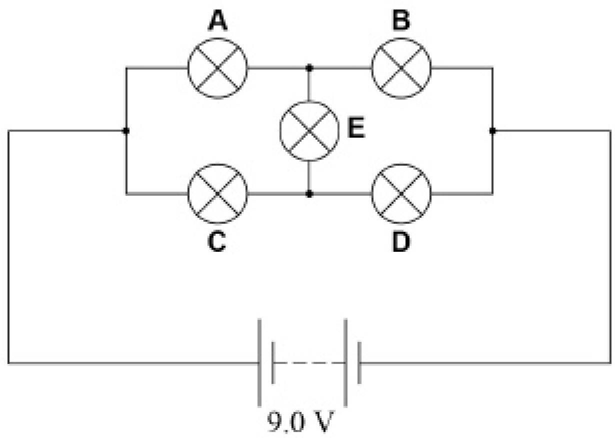
___

___

(4)

(b) The student connects another lamp **E** in the circuit as shown in **Figure 2**.
Lamp **E** is identical to lamps **A** and **C**.

Figure 2



Explain what the student would observe regarding the brightness of the lamps.

Refer to potential differences across lamp **E** in your answer.

(3)

(c) Lamp **B** in **Figure 2** fails so that it no longer conducts. This change does not affect the resistance of the other lamps.

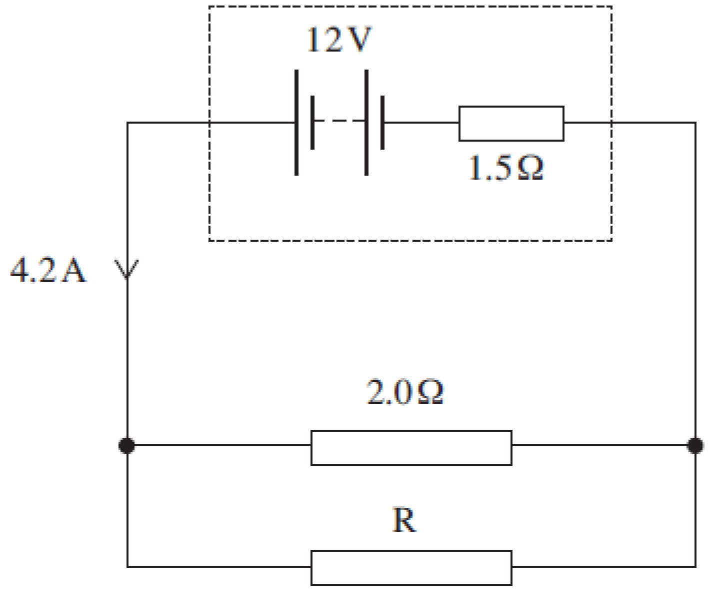
Deduce the effect on the current in the battery.

Use calculations to support your answer.

(3)

(Total 10 marks)

2 The circuit diagram below shows a battery of electromotive force (emf) 12 V and internal resistance 1.5 Ω connected to a 2.0 Ω resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.



(a) (i) Show that the potential difference (pd) across the internal resistance is 6.3 V.

(1)

(ii) Calculate the pd across the 2.0 Ω resistor.

pd ____________________ V

(1)

(iii) Calculate the current in the 2.0 Ω resistor.

current ____________________ A

(1)

(iv) Determine the current in R.

current ____________________ A

(1)

(v) Calculate the resistance of R.

R ____________________ Ω

(1)

(vi) Calculate the total resistance of the circuit.

circuit resistance ____________________ Ω

(2)

(b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

(i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	**rate of energy dissipation / W**
internal resistance	
2.0 Ω	
R	

(3)

(ii) Hence show that energy is conserved in the circuit.

____

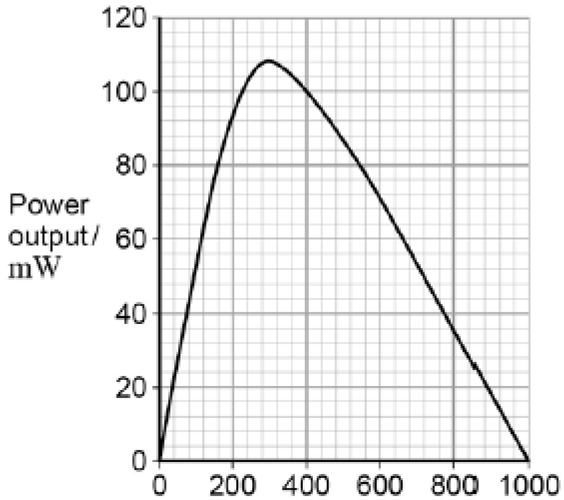
____

(2)

(Total 12 marks)

3 **Figure 1** shows data for the variation of the power output of a photovoltaic cell with load resistance. The data were obtained by placing the cell in sunlight. The intensity of the energy from the Sun incident on the surface of the cell was constant.

Figure 1



(a) Use data from **Figure 1** to calculate the current in the load at the peak power.

(3)

(b) The intensity of the Sun's radiation incident on the cell is 730 W m $^{-2}$. The active area of the cell has dimensions of 60 mm × 60 mm.

Calculate, at the peak power, the ratio $\frac{\text{electrical energy delivered by the cell}}{\text{energy arriving at the cell from the Sun}}$

(3)

(c) The average wavelength of the light incident on the cell is 500 nm. Estimate the number of photons incident on the active area of the cell every second.

(2)

(d) The measurements of the data in **Figure 1** were carried out when the rays from the sun were incident at 90° to the surface of the panel. A householder wants to generate electrical energy using a number of solar panels to produce a particular power output.

Identify **two** pieces of information scientists could provide to inform the production of a suitable system.

(2)

(Total 10 marks)

Mark schemes

1 (a) resistance of lamp B and D = $3.5^2/4.1 = 3.0$ (2.98)(Ω) ✓
resistance of lamp A and C = $6.0^2/6.0 = 6.0$ (Ω) ✓
pd across lamp B and lamp D = 3/9 × 9.0 = 3.0 (V) OR pd across lamp A and C = 6.0 (V) ✓
hence A and C normal brightness ✓

Can justify in terms of current i.e. current needed by A and C is 1 A provided resistance values calculated

Must have some correct working for conclusion mark

1
1
1
1

(b) the pd across new lamp = 0 / E does not light ✓
no current in E ✓
other lamps are not affected ✓
because the current in the lamps/pd across lamps does not change ✓

2^{nd} and 3^{rd} marks conditional on 1^{st} mark

1
1
1
(MAX 3)

(c) in first circuit current in battery = 9.0/4.5 = 2.0 A ✓
in second circuit current in battery = 9.0/7 = 1.2857 A ✓
hence current in battery decreases ✓

Allow ecf from (a)

Original current = 2A can come from (a) and score here

If say circuit resistance increases so current decreases and no other marks awarded score 1 mark

1
1
1

[10]

2 (a) (i) *(use of V=Ir)*
V= 4.2 × 1.5 ✓ = 6.3 (V)

1

(ii) pd = 12 − 6.3 = 5.7 V✓

NO CE from (i)

1

(iii) (*use of I = V / R*)
I = 5.7 / 2.0 = 2.8(5) A✓

CE from (ii)
(a(ii)/2.0)
accept 2.8 or 2.9

1

(iv) $I = 4.2 - 2.85 = 1.3(5)$ A ✓

CE from (iii)
(4.2 −(a)(iii))
accept 1.3 or 1.4

1

(v) $R = 5.7 / 1.35 = 4.2\ \Omega$ ✓

CE from (iv)
(a(ii) / (a)(iv))
Accept range 4.4 to 4.1

1

(vi) $$\frac{1}{R_{Parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$$ ✓

CE from (a)(v)

$R_{parallel} = 1.35\ \Omega$

second mark for adding internal resistance

$R_{total} = 1.35$ <u>+ 1.5</u>✓ $= 2.85\ \Omega$
OR
R = 12/4.2 ✓
R= 2.85 Ω ✓

2

(b) (i)

resistor	Rate of energy dissipation (W)
1.5 Ω internal resistance	$4.2^2 \times 1.5 = 26.5$✓
2.0 Ω	$2.85^2 \times 2.0 = 16.2$ (15.68 − 16.82)✓
R	$1.35^2 \times 4.2 = 7.7$ (7.1 − 8.2)✓

CE from answers in (a) but not for first value

2.0: a(iii)^2×2

R: a(iv)^2×a(v)

3

(ii) energy provided by cell per second = 12 × 4.2 = <u>50.4</u> (W) ✓
energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4 ✓
(hence energy input per second equals energy output)

if not equal can score second mark if an appropriate comment

2

[12]

3 (a) Peak power = 107 / 108 mW and load resistance = 290 / 310 Ω ✓

1

Use of power = I^2R with candidate values✓ **1**

0.0186 – 0.0193 A ✓ **1**

(b) Area of cell = 36 x 10^{-4} m^2 and solar power arriving = 730 × (an area)✓ **1**

$\frac{0.108}{2.63}$ seen✓ **1**

0.041 (correct answer only; lose if ratio given unit) ✓ **1**

(c) energy of one photon = $\frac{hc}{\lambda}$ = 4.0 ×10^{-19}J✓ **1**

Number of photons = $\frac{730 \times 36 \times 10^{-4}}{4.0 \times 10^{-19}}$ = 6.6 × 10^{18} s^{-1}✓ **1**

(d) **Two** from

Intensity of the sun at the Earth's surface
Average position of the sun
Efficiency of the panel
Power output of 1 panel
Weather conditions at the installation=
✓✓

Allow other valid physics answers= **2**

[10]