GCSE – NEW

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3440UA0-1

S18-3440UA0-1

APPLIED SCIENCE (Single Award)
UNIT 1: Science in the Modern World

HIGHER TIER

MONDAY, 11 JUNE 2018 – MORNING

1 hour 30 minutes

ADDITIONAL MATERIALS

In addition to this paper you will require a calculator, pencil and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **2**(a) is a quality of extended response (QER) question where your writing skills will be assessed.

You are reminded to show all your workings. Credit is given for correct workings even when the final answer given is incorrect.

A periodic table is printed on page 24.

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Answer **all** *questions.*

1. To get the greatest output from solar panels, they need to point in the direction that captures the most sun.

    The Northern Alberta Institute of Technology (NAIT) in Canada has designed a solar photovoltaic (PV) array consisting of six pairs of solar PV panels. They provide installers with information about how tilt angles and snow cover affects electrical output.

    After snowfall, the left hand side of the system is cleared of snow as shown below.

    No snow cover

    Points of interest from 2013-2014

    - highest single panel output energy for one day = 1.82 kWh

    - highest array output energy for one month = 442 kWh

    A group of students investigate how the power output from a solar PV cell depends on its tilt angle. The manufacturer of the solar cells makes the following claims.

    > maximum power output = 4 W
    > performance = 60%
    > area = 0.01 m^2
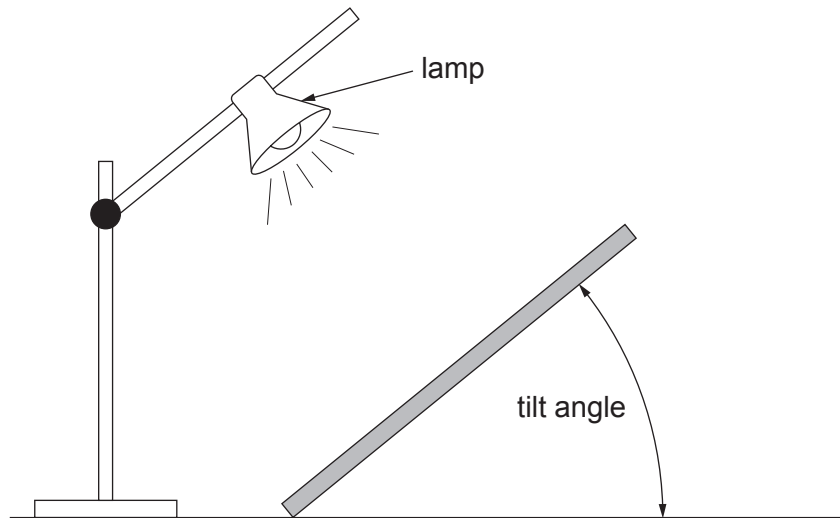
The results of their investigation are shown below.

Solar cell tilt angle (degrees)	Output voltage (V)	Output current (A)	Actual power output (W)
90	0.66	1.30	0.86
75	0.80	1.60	1.28
60	0.84	1.70	1.43
45	0.90	1.80	1.62
30	0.88	1.75	....
15	0.72	1.45	1.04
0	0.58	1.15	0.67

(a) Use the information above to answer the following questions.

(i) Use the equation:

power = voltage × current

to **complete** the table. [2]

(ii)   Use the data in the table to plot a graph on the grid below and draw a suitable line. [4]

Actual
power
output
(W)
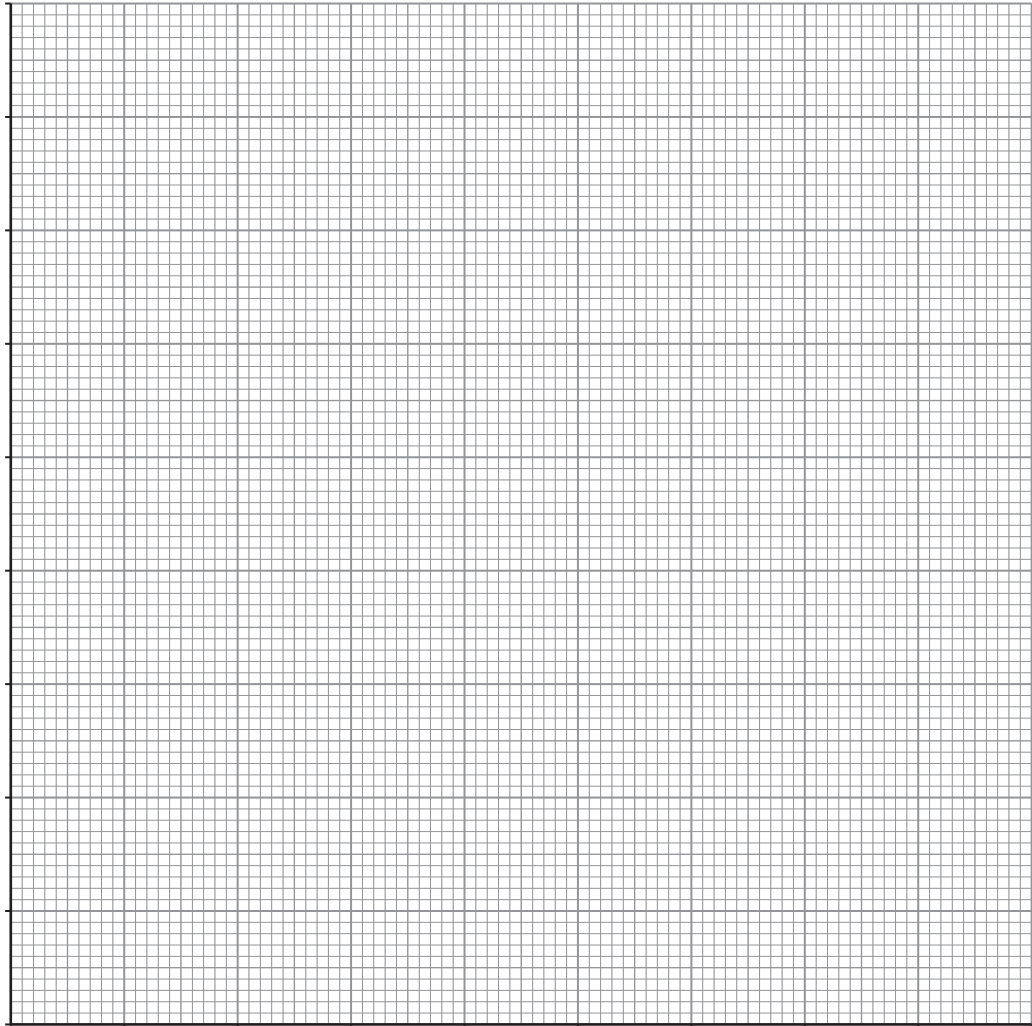
Tilt angle (degrees)

(iii)   Use your graph to answer the following questions.

I.   Estimate the power output for a tilt angle of 55°. [1]

Power output = ... W

II.   Describe the relationship between the actual power output of the PV cell and the tilt angle. [2]

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(b) (i) The manufacturer's claims about its solar panels are shown below.

maximum power output = 4 W
performance = 60%
area = 0.01 m^2

Use the table on page 4, the information above and the equation:

$$\% \text{ performance} = \frac{\text{actual power output}}{\text{claimed maximum power output}} \times 100$$

to decide whether the manufacturer's claim about the performance of the solar cell is valid. [3]

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....

(ii) The area of PV cells on the roof of a house is 5 m^2.
Calculate the maximum power output based on the manufacturer's claims. [2]

Maximum power output = ... W

(c) Suggest how the students could extend the investigation to study the effects of snow on the PV cells. [1]

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(d) Silicon (Si) is used in the production of solar PV cells. After oxygen, silicon is the second most abundant element in the Earth's crust. It is found as silica (silicon dioxide SiO_2). Silicon is produced by heating silica with carbon at a high temperature.

(i) Silica is reduced by heating with carbon. State what happens to silica during reduction. [1]

....

(ii) State in terms of electrons, what happens to the ions in silica during reduction. [1]

....

(iii) The word equation for the reaction is given below.

silicon dioxide + carbon $\longrightarrow$ silicon + carbon monoxide

Complete the **balanced** symbol equation below for this reaction. [2]

SiO_2 + ☐ .... $\longrightarrow$ Si + ☐ ....

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2. Grey Treefrogs *(Hyla versicolor)* and Green Treefrogs *(Hyla cinerea)* are found in the central and southeastern United States of America. Grey Treefrogs and Green Treefrogs seem to occupy the same habitat, but Grey Treefrogs live further north than Green Treefrogs. Grey Treefrogs prefer wooded areas while Green Treefrogs prefer more open wetland areas with leafy vegetation.

Grey Treefrogs

Food: mites, spiders, plant lice, harvestmen, snails
Predators: snakes, birds, large fish, other frogs

Green Treefrogs

Food: flies, mosquitoes, other small insects
Predators: snakes, birds, large fish, other frogs

Grey Treefrogs on tree bark   Green Treefrogs on leaves

Treefrogs

(a) Use the information to explain how each type of Treefrog is adapted to their habitat.

[6 QER]

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(b) (i) **Complete** the classification below for Green Treefrogs.   [1]

Kingdom:	Animalia
Phylum:	Vertebrae
Class:	Amphibia
Order:	Anura
Family:	Hylidae
Genus:	*Hyla*
Species:	....

(ii) State **one** advantage of using scientific names.   [1]

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3. Theories about the origin of the Universe have changed over time. The Big Bang theory was not always as popular as it is today. The Steady State theory is an alternative to the Big Bang model of the evolution of the Universe and was widely accepted in the mid-20th century. It is now rejected by the vast majority of astrophysicists and astronomers.

(a) Describe the Steady State theory of the evolution of the Universe. [3]

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(b) (i) One piece of evidence for the Big Bang theory is Cosmic Microwave Background Radiation (CMBR) which is found throughout the Universe.

Explain the existence of CMBR. [3]

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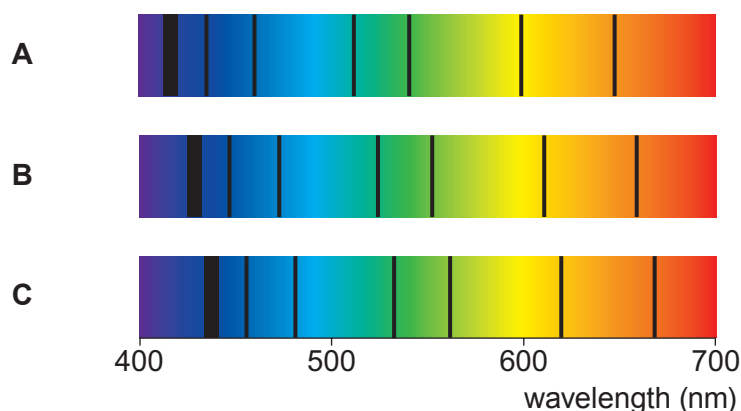...

(ii) Further evidence includes red shift observations of spectra. Spectrum **A** below is from our Sun. Spectra **B** and **C** are from two distant galaxies.

Explain how the spectra provide information to compare the composition of galaxies **B** and **C** and their motion relative to the Earth. [4]

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(3440UA0-1) **Turn over.**

4. Natural Resources Wales is responsible for managing and monitoring water quality in Wales. There are a number of factors that have an impact on water resources. These include population growth, pollution, an increased demand for water and climate change.

    (a) The number of organisms present in water is one indicator of pollution levels. A food web in the healthy river Clydach is shown in the diagram below. Currently there are herons living alongside one stretch of the river.
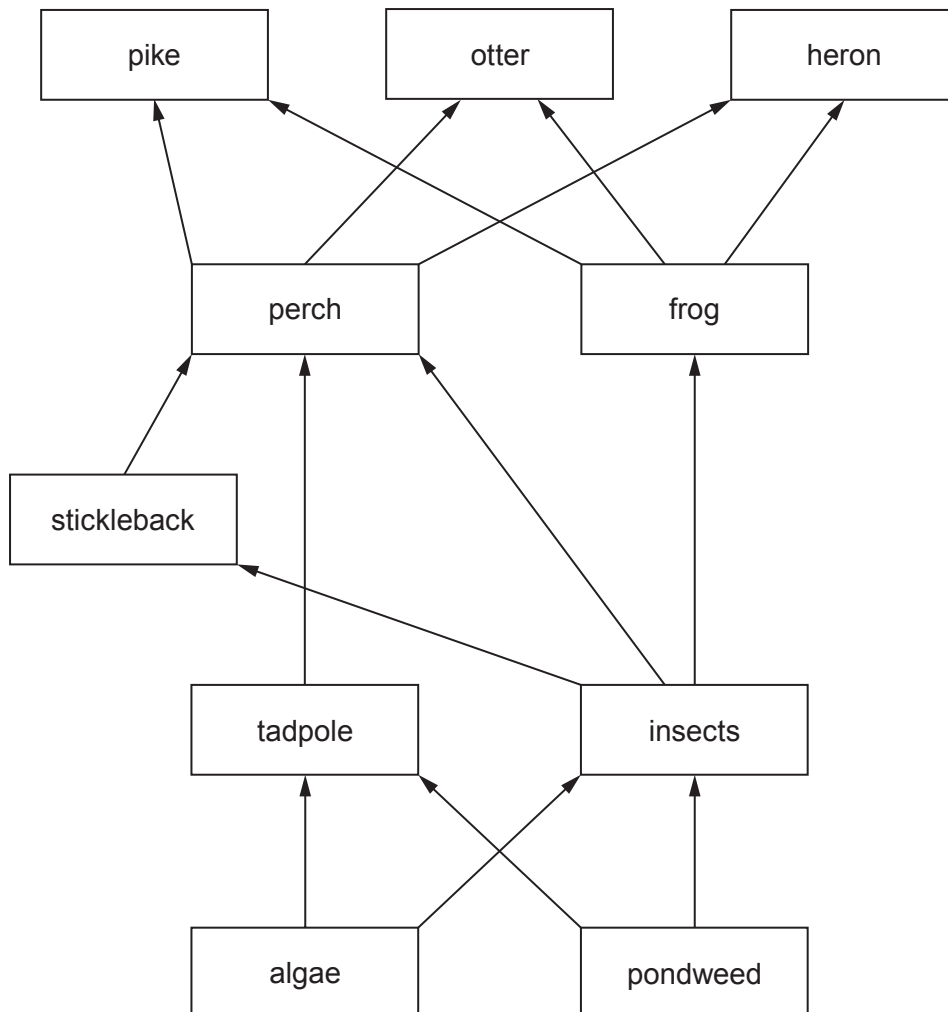
(i)   Explain how the population of pike in the river Clydach will be affected if the herons leave the area.   [4]

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(ii) Explain how eutrophication would affect the food web if the river Clydach becomes polluted with sewage.   [4]

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(b) During a routine inspection of the river Clydach dead fish are seen on the riverbank. Some unmarked, corroded metal drums are found in the river. They are removed and taken to a laboratory. When opened they are found to contain an unknown powder.

(i) After a series of chemical tests were performed on the powder the following results were obtained.

Test	Results
add sodium hydroxide solution	reddish-brown precipitate formed which is insoluble in excess sodium hydroxide solution
acidify then add barium chloride solution	white precipitate formed

Identify the compound present in the powder. [2]

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(ii) The tables show the formulae of some common ions.

Positive ions

Name	Formula
copper(II)	Cu^{2+}
zinc	Zn^{2+}
iron(II)	Fe^{2+}
iron(III)	Fe^{3+}
aluminium	Al^{3+}

Negative ions

Name	Formula
hydroxide	OH^-
nitrate	NO_3^-
oxide	O^{2-}
sulfide	S^{2-}
sulfate	SO_4^{2-}

Use the information above to state the chemical formula of the compound in the powder. [1]

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5. Chemical companies prepare compounds in their factories. One such compound is zinc sulfate which is important for treating people with zinc deficiency.

(a) Complete the **balanced** chemical equation, including state symbols for the reaction below that produces zinc sulfate. [2]

$$ZnO \ (s) \ + \ H_2SO_4 \ (aq) \longrightarrow \dotsb (\dotsb) \ + \ \dotsb (\dotsb)$$

(b) On an industrial scale, large quantities of solution need to be evaporated so dry zinc sulfate can be collected. This is an expensive part of the process. An electric heater with a power of 15 kW is used for a mean time of 50 hours per week.

Use the equations:

units used = power (kW) × time (h)

total cost = cost of one unit × units used

to calculate the cost of using the heater for **one year**. One unit of electricity costs 19 p. [3]

Cost = ...

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6. The composition of water from different sources varies.

(a) The table below gives information about the mineral content and pH of different types of bottled water samples A to H.

Water sample	A	B	C	D	E	F	G	H
pH	8.2	7.8	5.5	7.2	7.5	7.7	8.2	6.4
total mineral content (mg/dm^3)	385	559	595	480	270	1 109	237	22
calcium (mg/dm^3)	71.2	100.4	147.3	78.0	17.0	208.0	30.0	3.8
magnesium (mg/dm^3)	23.0	23.6	3.4	24.0	13.0	55.9	6.9	0.8
potassium (mg/dm^3)	2.2	0.7	0.6	1.0	0.0	2.7	0.9	0.0
bicarbonate (mg/dm^3)	75.7	344.2	390.0	357.0	140.0	135.5	100.0	0.0
sulfate (mg/dm^3)	200.4	59.3	33.0	0.0	0.0	549.2	21.4	0.0
silica (mg/dm^3)	3.6	7.4	0.0	13.5	83.0	9.0	8.2	0.0

Not all minerals contained in the water are shown.

Use the data in the table to answer the following questions.

(i) Explain which sample is the hardest. [2]

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....

....

(ii) State which sample is the weakest acid. .... [1]

(iii) Calculate the total mineral content in a **250 cm³** bottle of sample **D**. [2]

Total mineral content = ... mg

(b) A thermal spring is produced by geothermally heated groundwater that rises from the Earth's crust. There are thermal springs in many locations all over the world. Taff's Well thermal spring is one example in Wales. The temperature of 21.6 °C at Taff's Well spring, is over 10 °C warmer than the groundwater temperature of 11.3 °C in Wales.

The chemical content of spring water depends on its temperature. The solubility of some compounds in water at different temperatures is shown in the graph below.
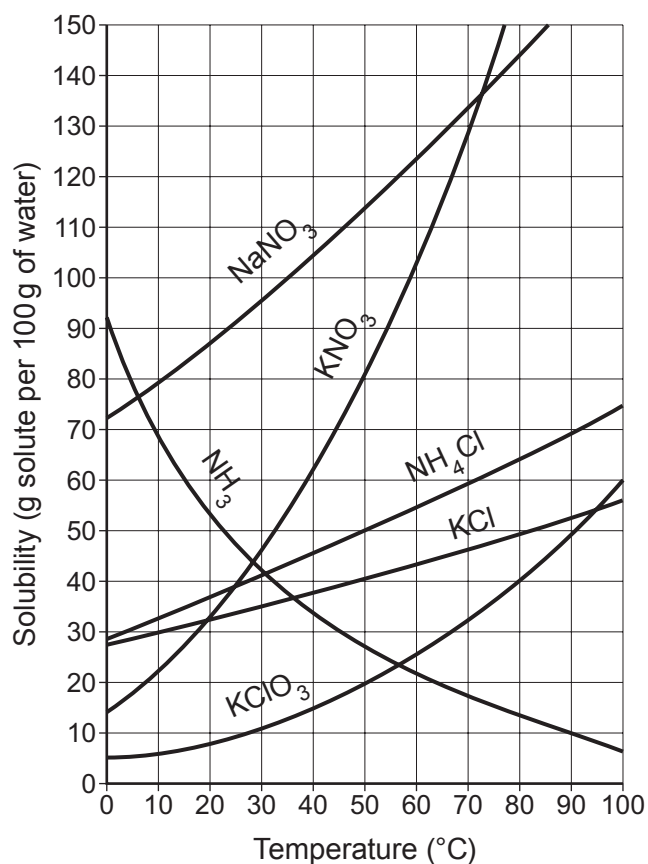
Use the information in the graph above to answer the following questions.

(i) State the compound which would be found at higher concentrations in groundwater in Wales than in the Taffs Well thermal spring water. [1]

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(ii) State which compound shows the smallest change in solubility from 0 °C to 100 °C. [1]

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(iii) Describe how the solubility of KNO_3 varies with temperature. [2]

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(iv) A 100 g sample of water at 50 °C is found to contain 70 g of $NaNO_3$

Is this a saturated solution? ....

Give **one** reason for your answer. [1]

(v) A saturated solution of $KClO_3$ is made in 50 g of water at 80 °C.
Calculate the mass of solid formed if the solution is cooled to 50 °C. [2]

mass = ... g

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7. Electricians need to understand how different types of circuit work.

Circuit 1 and **Circuit 2** show how three resistors R_1, R_2 and R_3 can be connected in parallel and series to a battery. The voltage, V_0, in each circuit is 12 V. The values of the resistors used are $R_1 = 8\,\Omega$, $R_2 = 12\,\Omega$, $R_3 = 24\,\Omega$.
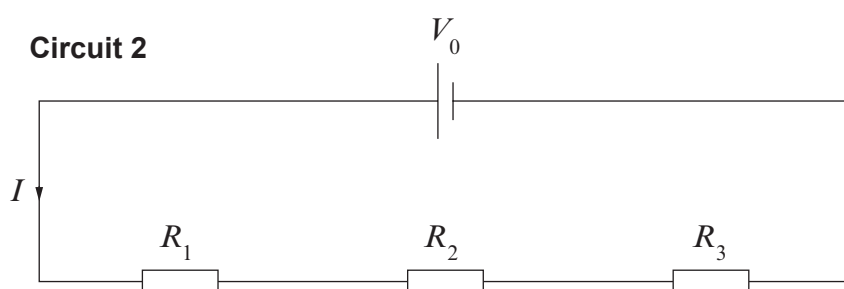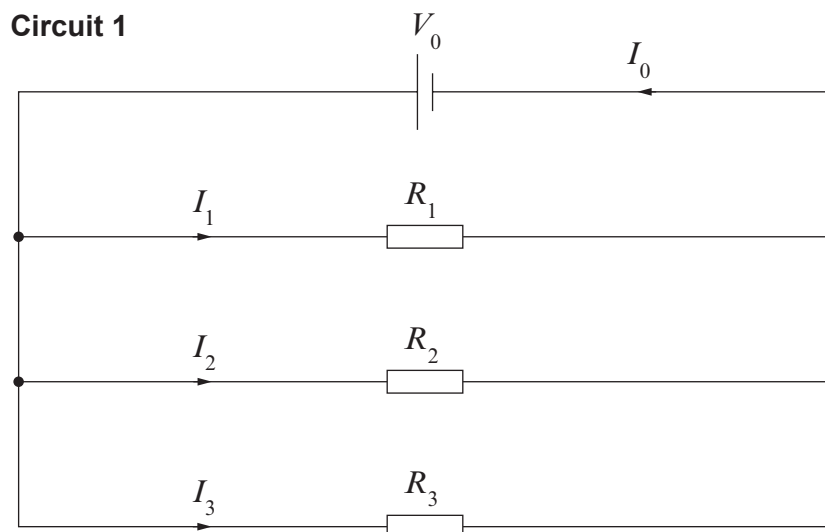
Circuit 1

Circuit 2

(a) Compare **Circuits 1** and **2** above:

(i) in terms of the **current** through the battery and each resistor. [2]

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....

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(ii) in terms of the **voltage** across the battery and each resistor. [2]

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(b) **Add** a voltmeter to **Circuit 1** to measure the voltage across R_2. [1]

(c) The electrician is told that current I_0 in **Circuit 1** is three times greater than current I in **Circuit 2** because three resistors are connected in parallel instead of series.

Use the equations:

$$R_T = R_1 + R_2 + R_3$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

voltage = current × resistance

to determine whether the electrician's information is correct. [5]

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THE PERIODIC TABLE

Group

1	2												3	4	5	6	7	0
																		4 He Helium 2
					1 H Hydrogen 1													
7 Li Lithium 3	9 Be Beryllium 4												11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12												27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30		70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48		115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80		204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89																

Key

A_r
Symbol — relative atomic mass
Name
Z — atomic number

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