Neap:

Trial Examination 2016

VCE Physics Unit 1

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of Booklet

Area of study	*Number of questions*	*Number of questions to be answered*	*Number of marks*
How can thermal effects be explained?	2	2	30
How do electric circuits work?	4	4	30
What is matter and how is it formed?	2	2	30
			Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, one folded A3 sheet or two A4 sheets of notes and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 19 pages including formulae, data and a periodic table at the front.

Instructions

Please ensure that you write your **name** and your **teacher's name** in the space provided on this booklet.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

FORMULAE

specific heat	$Q = mc\Delta t$
latent heat	$Q = mL$
Wien's law	$\lambda_{max} T = 2.9 \times 10^{-3}$ mK
Stefan–Boltzmann law	$P = kT^4$
first law of thermodynamics	$Q = \Delta U + W$
mass–energy equation	$E = mc^2$
power	$P = \frac{E}{t}$ or $P = Fv$
electrical charge	$Q = It$
electrical work	$W = QV$
charge on the electron	$e = -1.6 \times 10^{-19}$ C
voltage	$V = IR$
power	$P = VI$
resistors in series	$R_T = R_1 + R_2 \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots$
efficiency	efficiency (%) $= \frac{\text{useful energy output}}{\text{energy input}} \times 100$

DATA

speed of light in vacuum $= 3.0 \times 10^8$ m s^{-1}

1 eV $= 1.6 \times 10^{-19}$ J

PREFIXES

Prefix	Abbreviation	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

THE PERIODIC TABLE OF THE ELEMENTS

79	atomic number
Au	symbol of element
197.0	relative atomic mass
gold	name of element

1 **H** 1.0 hydrogen																	2 **He** 4.0 helium
3 **Li** 6.9 lithium	4 **Be** 9.0 beryllium											5 **B** 10.8 boron	6 **C** 12.0 carbon	7 **N** 14.0 nitrogen	8 **O** 16.0 oxygen	9 **F** 19.0 fluorine	10 **Ne** 20.2 neon
11 **Na** 23.0 sodium	12 **Mg** 24.3 magnesium											13 **Al** 27.0 aluminium	14 **Si** 28.1 silicon	15 **P** 31.0 phosphorus	16 **S** 32.1 sulfur	17 **Cl** 35.5 chlorine	18 **Ar** 39.9 argon
19 **K** 39.1 potassium	20 **Ca** 40.1 calcium	21 **Sc** 44.9 scandium	22 **Ti** 47.9 titanium	23 **V** 50.9 vanadium	24 **Cr** 52.0 chromium	25 **Mn** 54.9 manganese	26 **Fe** 55.8 iron	27 **Co** 58.9 cobalt	28 **Ni** 58.7 nickel	29 **Cu** 63.5 copper	30 **Zn** 65.4 zinc	31 **Ga** 69.7 gallium	32 **Ge** 72.6 germanium	33 **As** 74.9 arsenic	34 **Se** 79.0 selenium	35 **Br** 79.9 bromine	36 **Kr** 83.8 krypton
37 **Rb** 85.5 rubidium	38 **Sr** 87.6 strontium	39 **Y** 88.9 yttrium	40 **Zr** 91.2 zirconium	41 **Nb** 92.9 niobium	42 **Mo** 95.9 molybdenum	43 **Tc** 98.1 technetium	44 **Ru** 101.1 ruthenium	45 **Rh** 102.9 rhodium	46 **Pd** 106.4 palladium	47 **Ag** 107.9 silver	48 **Cd** 112.4 cadmium	49 **In** 114.8 indium	50 **Sn** 118.7 tin	51 **Sb** 121.8 antimony	52 **Te** 127.6 tellurium	53 **I** 126.9 iodine	54 **Xe** 131.3 xenon
55 **Cs** 132.9 caesium	56 **Ba** 137.3 barium	57 **La** 138.9 lanthanum	72 **Hf** 178.5 hafnium	73 **Ta** 180.9 tantalum	74 **W** 183.8 tungsten	75 **Re** 186.2 rhenium	76 **Os** 190.2 osmium	77 **Ir** 192.2 iridium	78 **Pt** 195.1 platinum	79 **Au** 197.0 gold	80 **Hg** 200.6 mercury	81 **Tl** 204.4 thallium	82 **Pb** 207.2 lead	83 **Bi** 209.0 bismuth	84 **Po** (209) polonium	85 **At** (210) astatine	86 **Rn** (222) radon
87 **Fr** (223) francium	88 **Ra** (226) radium	89 **Ac** (227) actinium	104 **Rf** (261) rutherfordium	105 **Db** (262) dubnium	106 **Sg** (263) seaborgium	107 **Bh** (264) bohrium	108 **Hs** (265) hassium	109 **Mt** (268) meitnerium	110 **Ds** (271) darmstadtium	111 **Rg** (272) roentgenium	112 **Uub**		114 **Uuq**		116 **Uuh**		118 **Uuo**

58 **Ce** 140.1 cerium	59 **Pr** 140.9 praseodymium	60 **Nd** 144.2 neodymium	61 **Pm** (145) promethium	62 **Sm** 150.3 samarium	63 **Eu** 152.0 europium	64 **Gd** 157.2 gadolinium	65 **Tb** 158.9 terbium	66 **Dy** 162.5 dysprosium	67 **Ho** 164.9 holmium	68 **Er** 167.3 erbium	69 **Tm** 168.9 thulium	70 **Yb** 173.0 ytterbium	71 **Lu** 175.0 lutetium
90 **Th** 232.0 thorium	91 **Pa** 231.0 protactinium	92 **U** 238.0 uranium	93 **Np** 237.1 neptunium	94 **Pu** (244) plutonium	95 **Am** (243) americium	96 **Cm** (251) curium	97 **Bk** (247) berkelium	98 **Cf** (251) californium	99 **Es** (252) einsteinium	100 **Fm** (257) fermium	101 **Md** (258) mendelevium	102 **No** (259) nobelium	103 **Lr** (260) lawrencium

Instructions for Section A

Answer **all** questions in the spaces provided. Write using black or blue pen.

Where an answer box has a unit printed in it, give your answer in that unit.

Where answer boxes are provided, write your final answer in the box.

In questions worth more than 1 mark, appropriate working should be shown.

Unless otherwise indicated, diagrams are not to scale.

Area of study – How can thermal effects be explained?

Data required for this section:

- *Specific heat capacity of water: 4180 J K^{-1} kg^{-1}*
- *Specific heat capacity of copper: 385 J K^{-1} kg^{-1}*
- *Specific heat capacity of steel: 466 J K^{-1} kg^{-1}*

Question 1 (17 marks)

Natasha, a Physics student, places two metal blocks labelled A and B on an insulated surface so they are in thermal contact, as shown in Figure 1.

Block A is made of copper and has a temperature of 100°C, and block B is made of steel and has a temperature of 100 K.

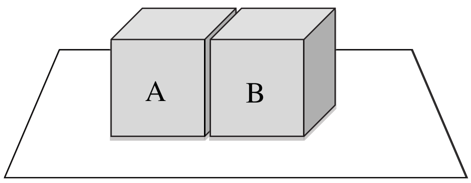

Figure 1

a. Which block, A or B, will have atoms with the greatest average kinetic energy? Give reasons for your choice. 2 marks

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Natasha now leaves the two blocks for a significant period of time. During this time, the blocks are touching until they reach thermal equilibrium with each other.

b. Explain, in terms of the Kinetic Theory of Matter, what is meant by the term 'thermal equilibrium' in this context. 1 mark

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Natasha now places both blocks on an electric heater as shown in Figure 2.

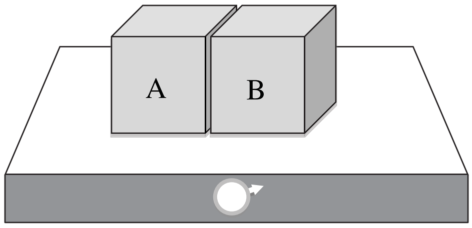

Figure 2

Natasha assumes that each block will *initially* receive the same heat energy from the heater's surface.

c. Explain why Natasha's assumption is a reasonable one. 3 marks

After a while Natasha again measures the temperatures of both blocks. She finds that they are now no longer the same temperature.

d. Predict which of the two blocks, A or B, will have reached a higher temperature, and explain why this block is hotter than the other. 3 marks

Once both blocks have reached a temperature of 500 K, Natasha cools block A (copper) by putting it in 1.0 kg of water at room temperature (25°C). After some time, the final temperature of block A and the water is 31°C.

e. Calculate the mass of block A. 2 marks

kg

The heater used by Natasha has two power settings of 1200 W and 2400 W. Natasha achieved a maximum surface temperature of 500 K using the 2400 W setting.

f. What maximum surface temperature would be achieved if she had used the 1200 W setting? 2 marks

K

At 500 K the surface of the heater would emit electromagnetic (EM) radiation.

g. Calculate the peak wavelength of the radiated EM energy at this temperature. 2 marks

nm

h. The radiation from the heater's surface at 500 K would be in the 2 marks

A. visible part of the EM spectrum.

B. microwave part of the EM spectrum.

C. UV part of the EM spectrum.

D. infrared part of the EM spectrum.

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Question 2 (13 marks)

Jordan is turning 17, and in preparation for his birthday he is inflating some balloons using hydrogen gas. He notices that as the gas expands the balloons, it also cools.

a. Show that Jordan's observation is consistent with the first law of thermodynamics. 3 marks

Hydrogen (H_2) is not considered a 'greenhouse gas'.

b. Explain how hydrogen is different to greenhouse gases (such as CO_2) in the way it interacts with EM radiation. 2 marks

The energy intensity from the Sun at one astronomical unit (radius of the Earth's orbit around the Sun) is 1360 W m^{-2}. The average heat received by the Earth from the Sun is 343 W m^{-2}.

c. Give two reasons why the average energy intensity is so much less than the energy intensity from the Sun. 2 marks

d. For the Earth to maintain a constant temperature, how much power per square metre must be radiated back into space? 1 mark

W m^{-2}

Saving energy at home is one way in which we can reduce the severity of climate change.

e. In what way is our home energy use linked to climate change? 2 marks

One of the ways to save energy at home is by using curtains to keep your house cool in summer instead of using air conditioning. Thick curtains of a light-coloured material with pelmets (Figure 3) are most effective.

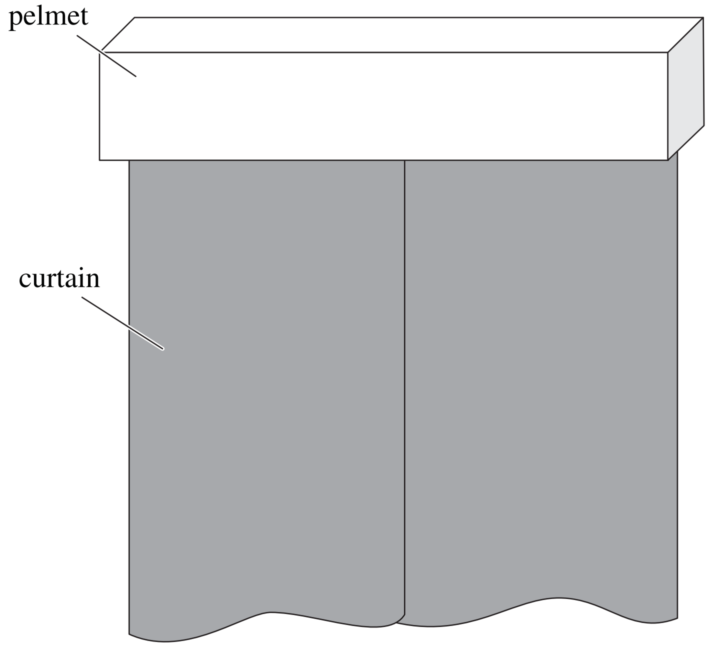

Figure 3

f. Explain why each of the aspects of curtains below will provide an effective barrier from the outside heat. In your answers, refer to each of the three forms of heat transfer.

thick curtains 1 mark

light-coloured curtains 1 mark

pelmets 1 mark

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Area of study – How do electric circuits work?

Question 3 (10 marks)

Antoine has the following electrical devices:

- 1 × 10.0 V DC battery
- 1 × 5.0 Ω resistor
- 2 × 10.0 Ω resistors
- connecting wires

a. Draw below, using the correct symbols, a fully labelled circuit that would provide the greatest electrical resistance. 2 marks

b. What is the total resistance in the circuit drawn in part **a.**? 1 mark

Ω

The circuit is now set up as shown in Figure 4.

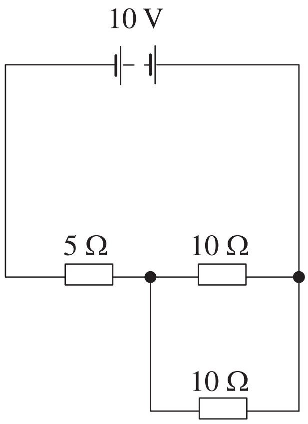

Figure 4

c. Fill in the table below with the relevant current and voltage drop values through each device. (Space has been left under the table for calculations.) 3 marks

	5 Ω	**10 Ω**	**10 Ω**
***I* (A)**			
***V* (voltage drop) (V)**			

Antoine is thinking of rearranging the circuit with the three resistors so that the power used will be a maximum.

d. In terms of series and parallel circuits, explain which set-up will produce this maximum. Support your answer with calculations. 4 marks

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Question 4 (9 marks)

Sofia constructs the circuit shown in Figure 5. The power supply is set to 12.0 V and the globe has a 6.0 W rating.

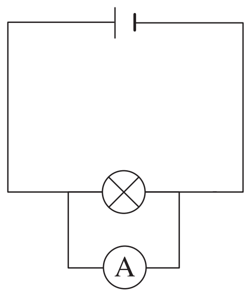

Figure 5

The globe is left on for five minutes.

a. How many coulombs of charge would be expected to be moving through the globe over this time? 2 marks

C

b. What amount of energy does Sofia expect the globe to consume if it is operating correctly? 2 marks

kJ

c. Explain the energy changes that occur as the charges pass through the globe. 1 mark

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On one occasion when Sofia turns on the power supply, the light globe fails to light up and the ammeter reading goes off the scale.

d. Explain what has most likely happened in this instance. 2 marks

e. What could Sofia do to make the light globe light up but still measure the current? You may use a diagram as part of your answer. 2 marks

Question 5 (8 marks)

An electrician asks her apprentice, Emma, to draw a simple circuit diagram for a study room that needs 2 × 80 W lights and one power point (Figure 6). S_1 and S_2 are on–off switches and the 240 V power supply is AC.

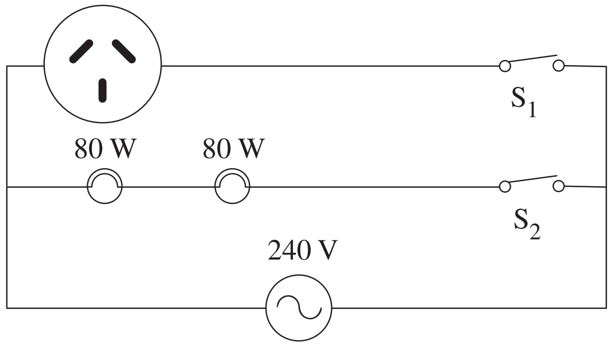

Figure 6

Emma needs to check the voltage across one of the globes.

a. Draw on Figure 6 where Emma should place the voltmeter. 1 mark

The electrician suggests that the globes should not be wired this way.

b. Can you suggest why, and what should be done to fix it? 2 marks

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c. If one of the light globes is used on average 1 hour and 45 minutes a day, what is the energy used over a two-week period? 2 marks

kW h

Emma does not think the power point needs the earth wire to run devices.

d. Explain if this assumption is correct or incorrect, but also include a reason why it should remain part of the circuit. 3 marks

Question 6 (3 marks)

A garden light typically has the following components:

- a solar panel that produces a DC voltage output
- a light-emitting diode (LED)
- a rechargeable battery
- a light-dependent resistance (LDR)
- a fixed-value resistor

Choose two devices from above and explain how one shows ohmic behaviour and the other non-ohmic behaviour.

Area of study – What is matter and how is it formed?

Question 7 (21 marks)

Most of the matter that makes up our visible universe is made of two groups of particles: baryons and leptons.

a. Give two examples of particles belonging to each of the following groups.

baryons 2 marks

leptons 2 marks

Early on in the history of the universe, about one minute after the Big Bang, nuclei formed. Atoms formed much later, about 300 000 years after the Big Bang.

b. Explain why it took many years before stable atoms could form in the early universe. 2 marks

The formation of atoms after 300 000 years also started a new stage for the universe. This stage can still be observed today as cosmic background radiation.

c. What property of the Universe changed to make this new stage possible? 1 mark

The Big Bang caused the creation of matter in the form of H (75%), He (25%) and a tiny amount of Li. Since the Big Bang, small amounts of heavier nuclei have also formed.

d. Which one of the following best describes the process and the place where these heavier nuclei were formed? 2 marks

	Process	Place
A.	nuclear fission	black holes
B.	nuclear fission	galactic centres
C.	nuclear fusion	core of stars
D.	nuclear fusion	surface of stars

The process referred to in part **d.** produces nuclei only up to iron (Fe).

e. What is special about iron (Fe) that prevents heavier nuclei from being produced using this process? 2 marks

Iron, like many other elements, exists as a variety of isotopes.

f. Explain what is meant by the term 'isotope'. 2 marks

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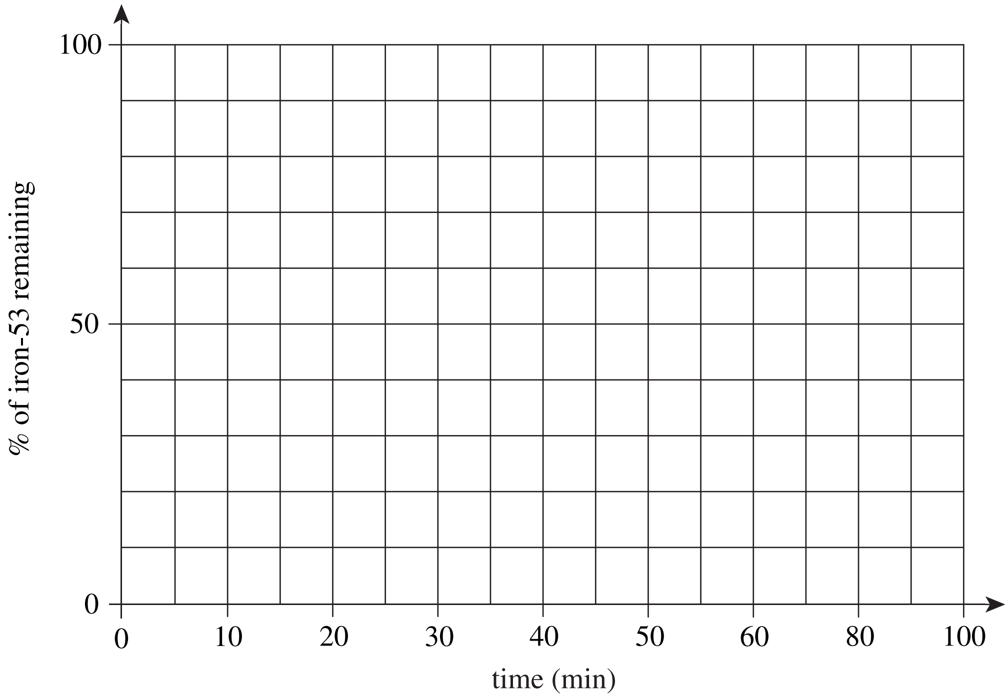
Iron-53 is a rare radioactive isotope of iron with a half-life of 8.0 minutes.

g. On the graph below, mark at least three points and complete a curve showing the decay of iron-53 over time. 3 marks



Fe-53 decays to Mn-53.

h. Using the periodic table provided, write the equation for the decay of Fe-53. 3 marks

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Manganese-53 itself is also radioactive, but it initially decays without undergoing transmutation to another element.

i. Explain what happens to the Mn-53 nucleus as it decays, and explain the nature of the emitted radiation. 2 marks

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Question 8 (9 marks)

Energy contained in the nucleus is many magnitudes greater than the energy associated with chemical reactions.

a. Explain the energy difference between nuclear and chemical reactions by referring to the forces that are involved in such reactions. 2 marks

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Currently, the most viable system to extract energy from the nucleus is through nuclear fission. Figure 7 shows a simplified version of a basic nuclear fission reaction.

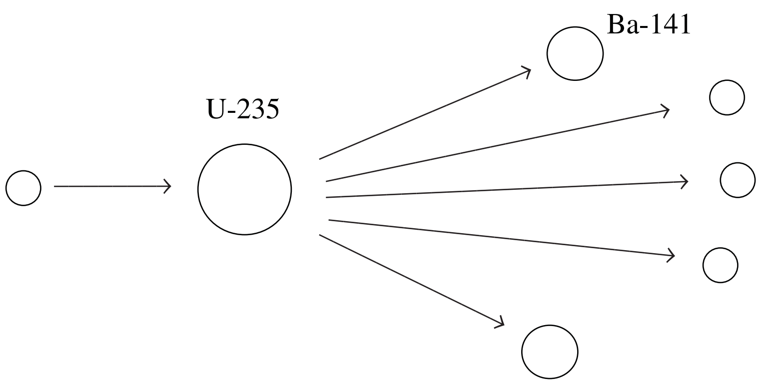

Figure 7

b. Write a complete nuclear equation for the reaction illustrated in Figure 7. You will need to use the periodic table provided. 3 marks

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The energy released in this reaction is 3.2×10^{-11} J.

c. Calculate the difference in mass between the products and reactants in this reaction. 2 marks

J

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Radioactive materials, such as the products produced in the reaction from part **b.**, sometimes glow in the dark.

d. Describe the process inside these atoms that are responsible for the production of such visible light. 2 marks

END OF QUESTION AND ANSWER BOOKLET