Neap

Trial Examination 2023

VCE Physics Unit 1

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	**A**	B	C	D
2	A	B	C	**D**
3	A	B	C	**D**
4	A	**B**	C	D
5	A	B	C	**D**
6	**A**	B	C	D
7	A	**B**	C	D
8	A	**B**	C	D
9	A	**B**	C	D
10	A	B	**C**	D

SECTION A – MULTIPLE-CHOICE QUESTIONS

Question 1 A

$$\lambda_{\max} T = b$$

$$T = \frac{2.9 \times 10^{-3}}{502 \times 10^{-9}}$$

$$= 5777 \text{ K}$$

$$= 5.78 \times 10^{3} \text{ K}$$

Question 2 D

$$c = f\lambda$$

$$f = \frac{3 \times 10^{8}}{250 \times 10^{-9}}$$

$$= 1.20 \times 10^{15} \text{ Hz}$$

Question 3 D

D is correct. Stars with a lower temperature emit a longer peak wavelength according to $\lambda_{\max} = \frac{b}{T}$. Longer wavelengths are associated with electromagnetic waves that have lower energy, such as infrared.

A, **B** and **C** are incorrect. These options are regions of the electromagnetic spectrum that have higher energy than visible light.

Question 4 B

B is correct. The neutron increases the amount of repulsion experienced between nucleons due to the strong nuclear force. Therefore, the amount of potential energy increases and the stability of the nucleus is reduced.

A is incorrect. The absorption of a neutron increases the mass number of the atom, not its atomic number.

C is incorrect. Although the nucleus does become more fissile, this is due to a decrease, not an increase, in binding energy. Adding a neutron increases the mass of a nucleus and thus decreases its binding energy.

D is incorrect. Adding a neutron to the nucleus decreases separation between nucleons, which results in increased repulsion due to the strong nuclear force.

Question 5 D

D is correct. Chain reactions are sustained due to the release of an exponentially increasing number of neutrons as the reaction continues. These neutrons are absorbed by other atoms, allowing them to undergo fission and thus continue releasing neutrons.

A is incorrect. The stability of fission products depends on their nuclear structure and binding energy, rather than their kinetic energy.

B is incorrect. Critical mass refers to the arrangement of fissile nuclei required to sustain a chain reaction by absorbing the neutrons emitted by each fission reaction. Critical masses must be composed of fissile nuclei rather than other particles.

C is incorrect. All particles can absorb heat from the reactor. The temperature of the reactor is related to the number of neutrons due to the subsequent fissions they cause, rather than their direct effect on heat in the reactor.

Question 6 A

A is correct. The short-term storage of radioactive waste prior to long-term disposal in Australia is a challenge due to the limited availability of local disposal sites.

B is incorrect. The exact products of fission cannot be predicted. While some resultant isotopes may be useful, there would still be a portion of the waste that needs to be disposed of.

C is incorrect. Efficient energy production cannot override other constraining factors such as disposal costs and environmental impact.

D is incorrect. While initial fission products may have short half-lives, the subsequent decay products may have longer half-lives that require long-term disposal.

Question 7 B

Resistance of the lower parallel branch:

$$R_{t_1} = 200 + 200$$
$$= 400\ \Omega$$
$$\frac{1}{R_{t_2}} = \frac{1}{400} + \frac{1}{400}$$
$$= \frac{1}{200}$$
$$R_{t_2} = 200\ \Omega$$

Equivalent resistance of the circuit:

$$R_T = 100 + 200$$
$$= 300\ \Omega$$

Question 8 B

$$V = IR$$
$$= 0.01 \times 400$$
$$= 4.0\ \text{V}$$

Question 9 B

$$R_{t_1} = 400\ \Omega$$

The equivalent resistance of the second branch is the same as the first branch. Each branch receives the same amount of voltage. As $I = \frac{V}{R}$, the magnitude of current flowing is also equal.

$$I = \frac{V}{R}$$
$$= \frac{4}{400}$$
$$= 0.010\ \text{A}$$

OR

Due to the equal resistance of both parallel branches, the same current flows in each branch.

Therefore, $I = 0.010$ A.

Question 10 C

C is correct. Elements in series share voltage. Therefore, the battery supplies enough voltage for both the parallel section of the circuit and the 100 Ω resistor.

A is incorrect. The 200 Ω resistor branch is in parallel with the 400 Ω resistor branch. Therefore, when current splits at the junction, individual electrons carry the same amount of energy that remains from the battery.

B is incorrect. The additional pathway affects the amount of current flowing through the battery, rather than the voltage it provides.

D is incorrect. Junctions affect the direction of current flow and individual charges retain the potential energy they already have. Therefore, junctions have no impact on voltage.

SECTION B

Question 1 (11 marks)

a. $n_1 \sin(\theta_i) = n_2 \sin(\theta_r)$

$\sin(60) = n_2 \sin(25.6)$ 1 mark

$n_2 = 2.00$ 1 mark

b. $n_1 \sin(\theta_i) = n_2 \sin(\theta_r)$

$\sin(60) = 2.42 \sin(\theta_r)$ 1 mark

$\theta_r = 21.0°$ 1 mark

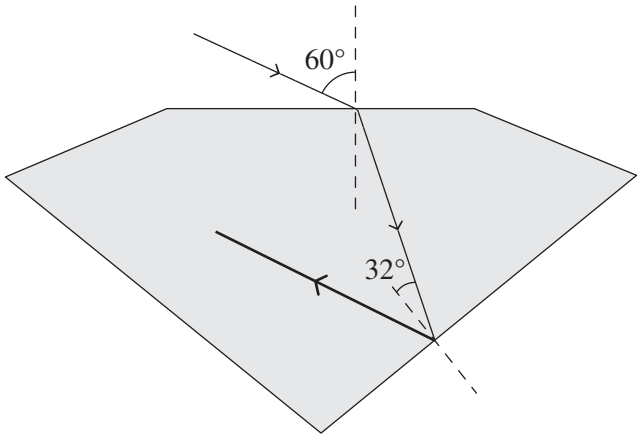
c. $n_1 \sin(\theta_c) = n_2 \sin(90)$

$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$ 1 mark

$= \sin^{-1}\left(\frac{1}{2.00}\right)$

$= 30°$ 1 mark

As $32° > 30°$, $\theta_i > \theta_c$. Therefore, internal reflection occurs. 1 mark



1 mark

Note: Consequential on answer to ***Question 1a.***

d. Rainbows are formed due to dispersion of colour when white light passes through the diamond. 1 mark

Each component of the light's wavelength has a different refractive index in the diamond. 1 mark

The components refract at different angles and follow different paths, thus splitting into different colours. 1 mark

Question 2 (9 marks)

a. The method of heat transfer that occurs between the Sun and the ice cream is radiation. 1 mark

For example, any one of:

- This is because no contact is between made between the two samples.
- This is due to electromagnetic waves being used to transmit energy.

1 mark

Note: Accept any reasonable justification.

b. $34.4 \times 10^3 = 34\,400 \text{ J}$

$\frac{125}{1000} = 0.125 \text{ kg}$

$Q = mL$

$34\,400 = 0.125L$ 1 mark

$L = 2.75 \times 10^5 \text{ J kg}^{-1}$ 1 mark

c. The phase change breaks the bonds between ice cream particles. 1 mark

This allows the particles to move more freely, allowing for greater vibration and thus increasing their kinetic energy and temperature. 1 mark

d. $Q = cm\left(T_f - T_i\right)$

$3150 = 2100 \times 0.125\left(T_f - 10\right)$ 1 mark

$T_f = 22°\text{C}$

$T = 22°\text{C}$

$T = (22 + 273.15) \text{ K}$ 1 mark

$T = 295.15 \text{ K}$ 1 mark

Note: 1 mark may be awarded for a correct conversion to kelvin using an incorrect T_f.

Question 3 (7 marks)

a. Urbanisation replaces forest vegetation with materials that can absorb heat more readily and increase in temperature more easily. 1 mark

The darker colour of the buildings and roads results in a greater range of wavelengths being absorbed, which increases the amount of energy that can be absorbed. 1 mark

The lower specific heat capacity of the materials causes the temperature of the buildings to rise more rapidly, resulting in a higher possible maximum temperature that can be reached more quickly. 1 mark

b. As the temperature of the air increases, the air expands and thus decreases in density, which causes the warm air to rise. This allows cooler, more dense air to flow and take its place. 1 mark

If the warmer regions on the land reach higher temperatures due to urbanisation, 1 mark
the strength of convection currents increases due to a greater volume of air moving upwards. 1 mark

A greater volume results in a stronger air current forming, which leads to stronger winds flowing to replace the air moving upwards. 1 mark

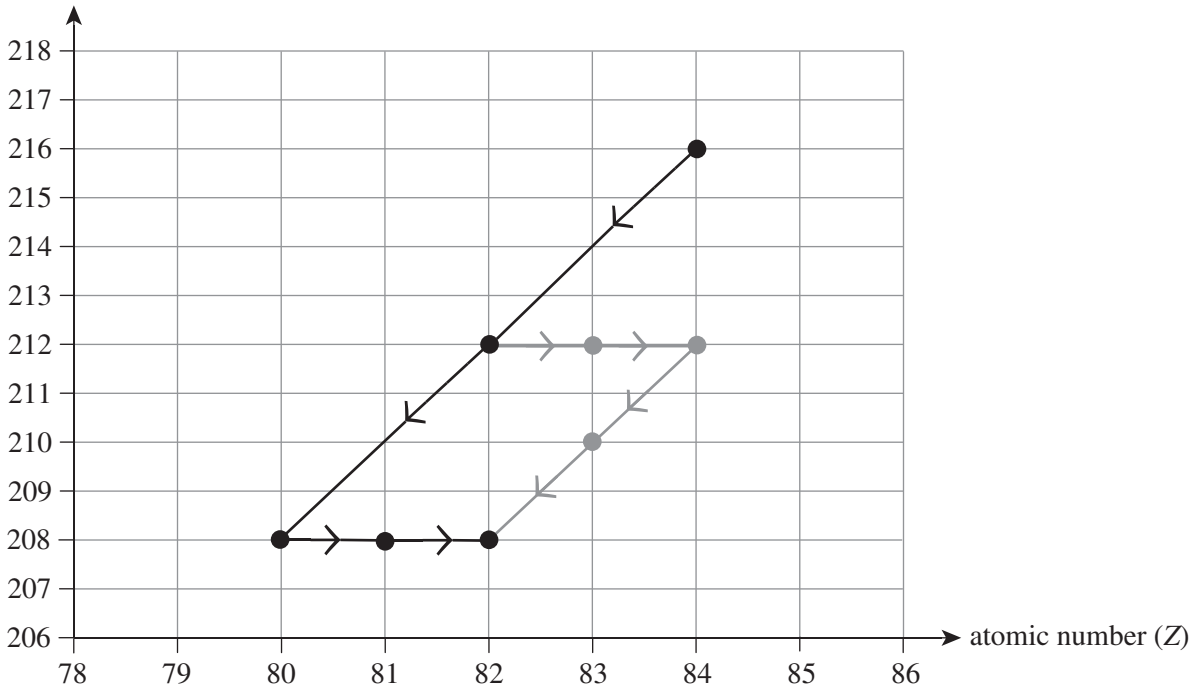
Question 4 (9 marks)

a. $216 - 2 \times 4 = 208$

$84 - (2 \times 2) + (2 \times 1) = 82$

Daughter nucleus: lead-208 1 mark

b. mass number



2 marks

1 mark for each possible decay series sketched.

c. ${}^{208}_{81}\text{Tl} \rightarrow {}^{208}_{82}\text{Pb} + {}^{0}_{-1}\beta + \nu_e^- + \text{energy}$

OR

${}^{212}_{84}\text{Po} \rightarrow {}^{208}_{82}\text{Pb} + {}^{4}_{2}\alpha + \text{energy}$

2 marks

1 mark for correct elements.

1 mark for correct radiation particles.

Note: The electron antineutrino does not need to be stated to be awarded the radiation particles mark.

d. During β^- decay, a neutron is converted to a proton. 1 mark

Both nucleons have a mass of 1. The produced β^- particle has a mass of 0. Therefore, the mass of the nucleus is unchanged. 1 mark

e. As the nucleons in the final daughter nucleus experience a greater strong nuclear force attraction compared to electrostatic repulsion, a stronger attraction between the nucleons occurs. 1 mark

A stronger attraction results in lower potential energy. 1 mark

Question 5 (13 marks)

a. ${}^{18}_{9}\text{F} \rightarrow {}^{18}_{8}\text{O} + {}^{0}_{1}\beta + v_e + \text{energy}$

2 marks
1 mark for correct elements.
1 mark for correct radiation particles.

b. Gamma rays are highly penetrating due to their fast movement and negligible size. 1 mark

Thus, gamma rays can travel through the spaces between cells with a low risk of collision; 1 mark
this presents a low risk to the patient. 1 mark

c. $DE = AD \times \text{quality factor}$

$16 \text{ mSv} = AD \times 1$

$AD = 16 \text{ mGy}$ 1 mark

$$AD = \frac{\text{energy}}{\text{mass}}$$

$$16 \times 10^{-3} = \frac{\text{energy}}{1.3}$$ 1 mark

$\text{energy} = 0.021 \text{ J}$ 1 mark

d. effective dose $= DE \times$ weighting factor

$ED_{\text{brain}} = 16 \times 0.01$
$= 0.16 \text{ mSv}$

$ED_{\text{kidney}} = 12 \times 0.009$
$= 0.108 \text{ mSv}$

$ED_{\text{bladder}} = 12 \times 0.04$
$= 0.48 \text{ mSv}$

1 mark
1 mark for calculating all three individual effective doses.

$ED_{\text{total}} = 0.16 + 0.108 + 0.48$
$= 0.75 \text{ mSv}$ 1 mark

e. $$A = \frac{A_0}{2^n}$$

$$12.5 \times 10^6 = \frac{0.2 \times 10^9}{2^n}$$ 1 mark

$2^n = 16$

$n = 4$ 1 mark

$t = nt_{\frac{1}{2}}$
$= 4 \times 2$
$= 8 \text{ hours}$ 1 mark

Question 6 (5 marks)

a. According to the binding energy graph, nucleons increase in binding energy when nuclei lighter than iron increase in mass or nuclei heavier than iron decrease in mass. 1 mark

Fission splits heavy nuclei into two daughter nuclei and fusion joins two lighter nuclei together. 1 mark

Both processes allow negative binding energy per nucleon to increase and therefore release energy. 1 mark

b. The mass of each nucleon decreases. 1 mark

When energy is released, the potential energy of each nucleon decreases; this is associated with a decrease in mass according to $E = mc^2$. 1 mark

Question 7 (11 marks)

a.
$$P = \frac{V^2}{R}$$
$$1200 = \frac{240^2}{R}$$ 1 mark
$$R = 48\ \Omega$$ 1 mark

b. Finding the current flowing through the blender gives:
$$P = VI$$
$$1200 = 240I$$
$$I = 5\ \text{A}$$ 1 mark

OR

Finding the charge using the resistance of the blender gives:
$$I = \frac{V}{R}$$
$$= \frac{240}{48}$$
$$= 5\ \text{A}$$ 1 mark
$$t = 12 \times 60$$
$$= 720\ \text{seconds}$$ 1 mark

Finding the charge flowing through the blender gives:
$$Q = It$$
$$= 5 \times 720$$
$$= 3600\ \text{C}$$ 1 mark

*Note: Responses that use the resistance of the blender are not awarded consequential marks if the resistance found in **Question 7a.** is incorrect.*

c. $P = \frac{E}{t}$

$E = Pt$

$= 1200 \times 720$

$= 8.64 \times 10^5 \text{ J}$ 1 mark

$P = \frac{1200}{1000}$

$= 1.2 \text{ kW}$

$t = \frac{12}{60}$

$= 0.2 \text{ h}$ 1 mark

$E = Pt$

$= 1.2 \times 0.2$

$= 0.24 \text{ kW h}$ 1 mark

d. A circuit breaker breaks the circuit when excess current flows. 1 mark

The circuit breaker is placed on the active wire to ensure that no current is able to flow into the blender if there is an electrical fault. 1 mark

This prevents a person who touches the blender from completing the circuit while voltage is running through it and thus causing electrocution. 1 mark

Question 8 (8 marks)

a. *Any one of:*

- Non-ohmic devices have variable resistance depending on voltage or current. 1 mark
  As seen in the graph, the resistance of the LED changes when the amount of voltage supplied changes and becomes undefined when voltage supplied exceeds the LED's forward voltage. 1 mark
- Ohmic devices have a constant resistance when either current or voltage is varied. 1 mark
  As seen in the graph, the LED does not have a constant resistance and therefore cannot be an ohmic device. 1 mark

b. $V_R = 4.5 - 1.8$

$= 2.7 \text{ V}$ 1 mark

$R = \frac{V}{I}$

$= \frac{2.7}{0.0139}$

$= 194.24 \, \Omega$ 1 mark

c. $P = VI$

$= 1.8 \times 0.0139$ 1 mark

$= 0.025 \text{ W}$ 1 mark

d. Reducing the resistance of the limiting resistor would increase the current flowing in the circuit, according to $I = \frac{V}{R}$. 1 mark

The increased current in the circuit would increase the power output of the LED according to $P = VI$. The LED would therefore produce more intense light. 1 mark

Note: Equations are not required for full marks but may be used to develop the response.

Question 9 (7 marks)

a. 45 000 Ω (*read from graph*) 1 mark

b. **Method 1:**

$1.5 : 4.5 = 45\ 000 : x$ 1 mark

$\frac{1}{3} = \frac{45\ 000}{x}$ 1 mark

$x = 135\ 000\ \Omega$ 1 mark

Method 2:

$V_{\text{out}} = \frac{V_{\text{in}} R_1}{R_1 + R_2}$

$1.5 = 6 \times \frac{45\ 000}{45\ 000 + R_2}$ 2 marks

1 mark for determining the voltage used by the resistor.
1 mark for showing appropriate working.

$R_2 = 135\ 000\ \Omega$ 1 mark

c. **Method 1:**

$157.5 \times 10^3 = 157\ 500\ \Omega$ 1 mark

$1.5 : 4.5 = x : 157\ 500$ 1 mark

$x = 52\ 500\ \Omega$

$T = 15°\text{C}$ (*read from graph*) 1 mark

Method 2:

$V_{\text{out}} = \frac{V_{\text{in}} R_1}{R_1 + R_2}$

$1.5 = 6 \times \frac{R_1}{R_1 + 157\ 500}$ 1 mark

$R_1 = 52\ 500\ \Omega$ 1 mark

$T = 15°\text{C}$ (*read from graph*) 1 mark