Neap

Trial Examination 2021

Suggested solutions

QCE Physics Units 1&2

Paper 1

SECTION 1 – MULTIPLE-CHOICE QUESTIONS

	A	B	C	D
1.	●	○	○	○
2.	○	○	●	○
3.	●	○	○	○
4.	○	○	●	○
5.	●	○	○	○
6.	○	○	○	●
7.	○	●	○	○
8.	○	●	○	○
9.	○	○	○	●
10.	○	○	○	●
11.	○	○	●	○
12.	○	○	○	●
13.	●	○	○	○
14.	●	○	○	○
15.	○	○	●	○
16.	○	●	○	○
17.	●	○	○	○
18.	○	○	●	○
19.	○	●	○	○
20.	○	○	●	○

QUESTION 1 A

As $T_C = T_K - 273$, the temperature of Betelgeuse in degrees Celsius is 3600 – 273 = 3327°C.

QUESTION 2 C

C is correct. The specific heat capacity of a substance is the amount of energy that must be transferred to decrease or increase the temperature of 1 kg of the substance by 1°C or 1 K. **A** is incorrect. Specific heat capacity refers to 1 kg of a substance, not 1 g. **B** and **D** are incorrect. These options specify that heat capacity is the amount of energy that must be transferred to either decrease or increase the temperature, not both.

QUESTION 3 A

$$\begin{aligned} Q &= mc\Delta t \\ &= 125 \times 4.18 \times 10^3 \times 30.0 \\ &= 15675000 \text{ J} \\ &= 15.675 \text{ MJ} \\ &\approx 15.7 \text{ MJ} \end{aligned}$$

QUESTION 4 C

C is correct. The ice goes through five phases. In phase V, the ice is still a solid, but a change in temperature is occurring. In phase W, there is no change in temperature as the solid particles separate into liquid (water). In phase X, the liquid is undergoing an increase in temperature from 0°C to 100°C. In phase Y, there is no change in temperature as the liquid particles separate into gas. In phase Z, the liquid has completely changed into a gas, and the temperature is increasing. **C** is the correct response as phases W and Y represent points where no change in temperature is occurring (but where solid particles are separating into liquid and liquid particles are separating into gas, respectively). By phase Z, the liquid has turned into a gas and temperature is increasing. **A**, **B** and **D** are incorrect. These options state that there is no change in temperature in phase V. This is incorrect as there is a temperature change from –30°C to 0°C.

QUESTION 5 A

A is correct. This option represents the helium particle $\left({}^{4}_{2}\text{He}\right)$ lost. This can be calculated by the loss from ${}^{241}_{95}\text{Am}$ to ${}^{237}_{93}\text{Np}$ as the mass number is reduced by 4 and the atomic number is reduced by 2. **B** and **C** are incorrect. ${}^{0}_{-1}e$ and ${}^{0}_{-1}\beta$ represent a beta particle (electron). **D** is incorrect. γ represents a gamma ray.

QUESTION 6 D

D is correct. The mass number of the element has not changed; it has stayed at 212. A beta particle $\left({}^{0}_{-1}\beta\right)$ and an electron antineutrino $\left({}^{0}_{0}\overline{v}_{e}\right)$ are emitted. **A** is incorrect. An electron antineutrino is emitted, but if a proton had been gained, the mass number would have changed. **B** is incorrect. While a beta particle is emitted, this option states that the mass number has changed, which it has not. **C** is incorrect. A beta particle and an electron antineutrino are emitted but, if the daughter nucleus had lost a proton, the mass number would have changed.

QUESTION 7 B

B is correct. The equation for energy efficiency is as follows.

$$\eta = \frac{\text{energy output}}{\text{energy input}} \times \frac{100}{1}\%$$

A is incorrect. This equation shows that any change in the internal energy (ΔU) of a system is equal to the energy added by heating ($+Q$) or removed by cooling ($-Q$) plus the work done by ($-W$) or on ($+W$) the system. **C** is incorrect. This is an equation for mass difference. **D** is incorrect. This is the equation for binding energy.

QUESTION 8 B

$$\begin{aligned} N &= N_0\left(\frac{1}{2}\right)^n \\ &= \left(3.0\times10^{18}\right)\times\left(\frac{1}{2}\right)^5 \\ &= 9.4\times10^{16} \text{ atoms} \end{aligned}$$

QUESTION 9 D

If $V = 3.00$ and $I = 0.375$ per the table:

$$\begin{aligned} V &= IR \\ 3.0 &= 0.375R \\ R &= \frac{3.0}{0.375} \\ &= 8.00\ \Omega \end{aligned}$$

QUESTION 10 D

D is correct. Alpha decay is the loss of a helium atom by the equation ${}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^{4}_{2}\text{He}.$ The mass numbers and atomic numbers must be conserved (210 = 206 + 4 and 84 = 82 + 2). **A** is incorrect. Alpha particles are helium nuclei, not hydrogen nuclei. **B** is incorrect. When carbon-14 undergoes beta negative decay, a nitrogen atom is formed, not a carbon atom; the equation should read ${}^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}_e.$ **C** is incorrect. An electron is emitted from the nucleus in beta negative decay, not in alpha decay.

QUESTION 11 C

C is correct. The graph shows that the current flowing through a resistor is proportional to the voltage across the resistor. As the voltage increases, so does the current. If a conductor is ohmic, the graph will be a straight line passing through the origin. **A** is incorrect. This graph shows an increase in current, then a decrease as voltage increases. **B** is incorrect. This graph shows the current remaining the same as voltage increases. **D** is incorrect. In this graph, there is a large amount of current flowing with no voltage, then a general decrease in current. This is not ohmic behaviour.

QUESTION 12 D

$$V = \frac{W}{q}$$
$$V = 12$$
$$q = 6.0$$
$$12 = \frac{W}{6.0}$$
$$\begin{aligned} W &= 12 \times 6.0 \\ &= 72 \text{ J} \end{aligned}$$

QUESTION 13 A

A is correct. The cyclist travelled 100 m over 20 seconds, which gives a velocity of $\frac{100}{20} = 5 \text{ m s}^{-1}$. **B** is incorrect. The cyclist was moving between A and B and between C and D as the gradient was positive. Between D and E, there was no change in position, so it is the only correct statement of the three. **C** is incorrect. The cyclist moved between A and B with a velocity of 5 m s^{-1}. Between C and D, the cyclist travelled 200 m over 20 seconds, which gives a velocity of $\frac{200}{20} = 10 \text{ m s}^{-1}$. Therefore, the cyclist was moving faster between C and D. **D** is incorrect. The cyclist was decelerating between E and F as the gradient is negative. The cyclist travelled 300 m over 20 seconds, which gives a velocity of $\frac{300}{20} = 15 \text{ m s}^{-1}$. Therefore, the cyclist was travelling faster between E and F than between A and B.

QUESTION 14 A

A is correct. The table exerts normal force upward to the box, and gravity exerts force downward onto the box. Normal force and gravitational force are always against each other. **B** is incorrect. The downward force is due to gravity, not acceleration. **C** is incorrect. Normal force is always against gravitational force, but they are ordered incorrectly in this option. **D** is incorrect. Normal force is always against gravitational force. Tension would be found in a string, cable or rope as a pulling force.

QUESTION 15 C

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ -50 &= 0 \times t + \frac{1}{2}(-9.8) \times t^2 \\ -50 &= -4.9t^2 \\ t &= \sqrt{\frac{-50}{-4.9}} \\ &= 3.19 \\ &\approx 3.2 \text{ s} \end{aligned}$$

QUESTION 16 B

$$\begin{aligned} v &= f\lambda \\ 9.0 &= f \times 1.5 \\ f &= \frac{9.0}{1.5} \\ &= 6.0 \text{ Hz} \end{aligned}$$

QUESTION 17 A

A is correct. Air is a less dense medium than water, so the light ray will travel faster and be refracted away from the normal. **B** is incorrect. As the angle of incidence increases, the angle of refraction also increases proportionally to the increase of incidence. **C** is incorrect. When light travels from air to a more optically dense medium, it will travel slower. **D** is incorrect. The speed of light in a vacuum is 3×10^8 m s^{-1}.

QUESTION 18 C

C is correct. For medium C, the light ray is bent the most towards the normal, so it has the highest refractive index. **A** is incorrect. In going from glass to medium A, the light does not appear to be refracted, so the refractive index of A must be close to that of glass. **B** and **D** are incorrect. Media B and D have refractive indexes less than that of glass. In both cases, in going from glass to the medium, the light is refracted away from the normal.

QUESTION 19 B

B is correct. The wavelength is the distance between points B and E. This is the distance between two successive points in phase. **A** is incorrect. The distance between points C and F represents the distance of parts of the wave at zero distance from the source. **C** and **D** are incorrect. Both options represent arbitrary lengths.

QUESTION 20 C

The area under the force–displacement curve gives the work done; therefore, the total area is the area of two triangles and a rectangle.

$$\begin{aligned}\text{total area} &= (20\times 10)+2\left(\frac{1}{2}\times 10\times 10\right)\\ &= 200+100\\ &= 300.0\ \text{J}\end{aligned}$$

SECTION 2

QUESTION 21 (4 marks)

a) $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{150.0} + \frac{1}{200.0}$$ *[1 mark]*

$$= \frac{7}{600.0}$$

$$R_t = \frac{600.0}{7}$$

$$= 85.71\ \Omega$$ *[1 mark]*

b) 150.0 Ω resistor:

$$I_{150} = \frac{V}{R}$$

$$= \frac{12.0}{150.0}$$

$$= 0.08\ \text{A}$$

200.0 Ω resistor:

$$I_{200} = \frac{V}{R}$$

$$= \frac{12.0}{200.0}$$

$$= 0.06\ \text{A}$$

[1 mark]

Award 1 mark for calculating both currents.

Therefore, the 150.0 Ω resistor has the greater current flowing through it. *[1 mark]*

QUESTION 22 (4 marks)

$$\text{mass of water} = 98.69\ \text{g}$$
$$= 0.09869\ \text{kg}$$

$$c_{\text{w}} = 4.18 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$$

$$\text{heat gained by the water} = mc\Delta t$$
$$= 0.09869 \times 4.18 \times 10^3 \times (30 - 25.2)$$ *[1 mark]*
$$= 0.09869 \times 4.18 \times 10^3 \times 4.8$$
$$= 1980.116\ \text{J}$$ *[1 mark]*

$$\text{heat gained by the water} = \text{heat lost by the metal}$$
$$1980.116 = mc\Delta t$$
$$= 0.07146 \times c \times (100 - 30)$$ *[1 mark]*
$$= 0.07146 \times c \times 70$$
$$c = \frac{1980.116}{0.07146 \times 70}$$
$$= 395.85\ \text{J kg}^{-1}\ \text{K}^{-1}$$ *[1 mark]*

QUESTION 23 (3 marks)

For example:

In nuclear fission, a large nucleus such as ${}^{238}_{92}\text{U}$ is forced to split into at least two fragments that are approximately equal in size. This occurs as a result of the release of neutrons and energy. A small amount of mass is converted to energy. An example of nuclear fission is the decay of ${}^{238}_{92}\text{U}$, which initially decays to ${}^{234}_{90}\text{Th}$ through alpha decay in 4.468×10^9 years, after which the decay process continues. *[1 mark]*

In nuclear fusion, lighter elements such as ${}^{2}_{1}\text{H}$ and ${}^{3}_{1}\text{H}$ can fuse to form ${}^{4}_{2}\text{He}$ through the release of energy and a single neutron. The energy created is usually less than that created by nuclear fission, but the energy per mass of reactants is much higher. *[1 mark]*

Nuclear fusion occurs when the number of nucleons is low. More energy is released per nucleon during nuclear fusion because the reactants are small atoms with fewer particles in the nucleus. *[1 mark]*

Note: Responses must refer to two elements shown in the graph to receive full marks.

QUESTION 24 (3 marks)

displacement = area under the velocity–time graph

$$\text{area} = \left(\frac{1}{2} \times 4 \times 8\right) + (4 \times 8) + \left(\frac{1}{2} \times 4 \times 4\right) + (12 \times 12)$$ *[1 mark]*
$$= 16 + 32 + 8 + 144$$ *[1 mark]*
$$= 200.0\ \text{m}$$ *[1 mark]*

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QUESTION 25 (3 marks)

Young projected a narrow beam of light through a pair of closely spaced holes (slits) in a darkened room. The light was viewed on a screen some distance away.

Diffraction occurred at the slits. If the light had produced a very bright region on the screen, this would have supported the particle nature of light. *[1 mark]*

Young observed that where the two beams of light fell on the screen, there was a series of alternating bright and dark fringes. This interference pattern is characteristic of waves. *[1 mark]*

Young suggested that constructive interference occurred at each bright band and destructive interference occurred at each dark band. *[1 mark]*

QUESTION 26 (4 marks)

a) The rate of change is the gradient of the graph.

The kinetic energy declines from 40 J to 0 J in 6 seconds.

Finding the gradient from point (8, 40) to (14, 0) gives:

$$\begin{aligned}\text{gradient} &= \frac{\text{difference in } y \text{ values}}{\text{difference in } x \text{ values}}\\ &= \frac{40-0}{14-8}\\ &= \frac{40}{6}\end{aligned}$$

[1 mark]

$$= 6.7 \text{ J s}^{-1}$$

[1 mark]

b) between 4 s and 8 s = 20 J

between 8 s and 14 s = 40 J *[1 mark]*

$$\begin{aligned}\text{total work done} &= 20+40\\ &= 60 \text{ J}\end{aligned}$$

[1 mark]

QUESTION 27 (4 marks)

Before the collision:

$m_1 = 1200 \text{ kg}$

$u_1 = 16.66 \text{ m s}^{-1}$

$m_2 = 800 \text{ kg}$

$u_2 = 0 \text{ m s}^{-1}$

$$\begin{aligned}\sum \text{before} &= (m_1 u_1) + (m_2 u_2)\\ &= (1200 \times 16.66) + (800 \times 0)\\ &= 19\,992 \text{ kg m s}^{-1}\end{aligned}$$ *[1 mark]*

After the collision:

$m_1 = 1200 \text{ kg}$

$u_1 = ? \text{ m s}^{-1}$

$m_2 = 800 \text{ kg}$

$u_2 = 11 \text{ m s}^{-1}$

$$\begin{aligned}\sum \text{after} &= (m_1 u_1) + (m_2 u_2)\\ &= (1200 \times ?) + (800 \times 11)\end{aligned}$$ *[1 mark]*

Note: Momentum is the product of an object's mass and velocity. When objects collide, momentum is conserved. That is, the momentum that both objects had before a collision is the same as that afterwards. The masses of the objects do not change but the velocities do.

The total momentum before the collision needs to be compared to the momentum after the collision. In this case, the velocity of car B increases from 0 m s^{-1} to 11 m s^{-1}.

$$19\,992 = (1200 \times V) + (800 \times 11)$$ *[1 mark]*

$$\begin{aligned}V &= 9.3267 \text{ m s}^{-1}\\ &= 9.3 \text{ m s}^{-1}\end{aligned}$$

Therefore, the velocity of car A after the collision is 9.3 m s^{-1}. *[1 mark]*

