Neap

Trial Examination 2021

Suggested solutions

QCE Physics Units 3&4

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 B

B is correct. All inertial frames of reference travel at constant velocity. **A** is incorrect. Travelling at constant speed could involve a change in velocity through direction. **C** is incorrect. Inertial frames of reference do not accelerate. **D** is incorrect. Inertial frames of reference travel at constant velocity relative to an observer.

QUESTION 2 A

A is correct. The W and Z bosons mediate the weak interaction. **B** is incorrect. The photon relates to the electromagnetic interaction. **C** is incorrect. The gluon relates to the strong interaction. **D** is incorrect. The W and Z bosons relate to the weak interaction, not the strong interaction.

QUESTION 3 C

C is correct. The magnetic field due to the magnet is to the left. The magnetic field due to the wire is vertically downwards. The sum of these two vectors corresponds to the direction indicated by **C**. **A**, **B** and **D** are incorrect. Geometrically, these options cannot be correct.

QUESTION 4 D

D is correct. The net force is centripetal. **A**, **B** and **C** are incorrect. At the position shown, the net force is the centripetal force that points towards the centre of the circle. Geometrically, these options cannot be correct.

QUESTION 5 D

Using Newton's Law of Universal Gravitation:

$$F = \frac{GMm}{r^2} \qquad \text{where } M = m$$

$$6.67 = \frac{6.67 \times 10^{-11} \times m^2}{[1000 \times 10^3]^2}$$

$$m^2 = 1 \times 10^{23}$$

$$m = 3.16 \times 10^{11} \text{ kg}$$

QUESTION 6 C

Using Coulomb's Law:

$$F = \frac{kQq}{r^2}$$

$$= \frac{9.0 \times 10^9 \times 1.0 \times 10^{-6} \times 2.0 \times 10^{-6}}{[1.0 \times 10^{-2}]^2}$$

$$= 1.8 \times 10^2 \text{ N}$$

QUESTION 7 C

$$B = \frac{\mu_0 I}{2\pi r}$$
$$= \frac{4\pi \times 10^{-7} \times 1.0}{2\pi \times 0.050}$$
$$= 4.0 \times 10^{-6} \text{ T}$$

QUESTION 8 B

B is correct. The two particles shown in the diagram are e^- and e^+, an electron and a positron. **A** is incorrect. The interaction is not between two electrons. **C** and **D** are incorrect. Protons and neutrons are not shown in the diagram.

QUESTION 9 A

A is correct. Kepler's second law states that the radius vector from the Sun to a planet sweeps out equal areas in equal times. **B** is incorrect. This option represents Kepler's third law. **C** is incorrect. This option represents Newton's Law of Universal Gravitation. **D** is incorrect. This option represents Kepler's first law.

QUESTION 10 C

The observed length of 250.5 m is the contracted length as the stationary observer measures the spacecraft travelling past them.

$$L = L_0 \sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$
$$250.5 = L_0 \sqrt{\left(1 - 0.87^2\right)}$$
$$= L_0 \times 0.49305$$
$$L_0 = 508.1 \text{ m}$$

QUESTION 11 A

A is correct. Intercept A is the stopping voltage needed to prevent the fastest electrons passing into the vacuum tube anode. A graph of this profile for the photoelectric effect has the *x*-axis as the voltage. Electrons are emitted from the photocathode and the other electrode is therefore the anode. **B**, **C** and **D** are incorrect. These options are not features that exist on the graph.

QUESTION 12 B

$$\text{work done} = qV$$
$$= 1.6 \times 10^{-19} \times 12$$
$$= 1.92 \times 10^{-18} \text{ J}$$

QUESTION 13 B

$$p = \frac{h}{\lambda}$$
$$= \frac{6.626 \times 10^{-34}}{560 \times 10^{-9}}$$
$$= 1.18 \times 10^{-27} \text{ N s}$$

QUESTION 14 D

D is correct. The *x*-axis represents the direction of travel. The *y*-axis represents the electric field. The *z*-axis represents the magnetic field. **A** and **B** are incorrect. These options do not reflect the correct quantities of the axes shown. **C** is incorrect. Conventionally, the wave is drawn such that if it travels to the right, the electric field is in the vertical plane and the magnetic field oscillates in the horizontal plane.

QUESTION 15 B

$$g = \frac{\text{constant}}{r^2}$$
$$8.30 = \frac{\text{constant}}{r^2}$$

Let r become $3r$.

$$g_{\text{new}} = \frac{\text{constant}}{(3r)^2}$$
$$= \frac{\text{constant}}{9r^2}$$
$$= \frac{8.30\, \cancel{r^2}}{9\, \cancel{r^2}}$$
$$= \frac{8.30}{9}$$
$$= 0.92 \text{ N kg}^{-1}$$

QUESTION 16 A

$$\text{horizontal component} = 20.0 \times \sin(25°)$$
$$= 8.45 \text{ N}$$

QUESTION 17 D

Using Wien's law:

$$\lambda = \frac{2.898 \times 10^{-3}}{\text{temperature (K)}}$$
$$\text{temperature} = \frac{2.898 \times 10^{-3}}{550 \times 10^{-9}}$$
$$= 5269 \text{ K}$$

The equivalent temperature in degrees Celsius is not shown: $5269 \text{ K} - 273 = 4996°\text{C}$.

QUESTION 18 B

B is correct. Magnetic flux is the product of the magnetic field strength and the area ($\Phi = B \times A$). **A** is incorrect. This option only represents the magnetic field strength. **C** is incorrect. This option represents the ratio of magnetic field strength per area. **D** is incorrect. This option represents a change in magnetic field strength.

QUESTION 19 B

Using the transformer ratio:

$$\frac{V_{\text{output}}}{V_{\text{input}}} = \frac{n_{\text{output}}}{n_{\text{input}}}$$

$$V_2 = 12 \times \frac{300}{900}$$

$$= 4.0 \text{ V}$$

QUESTION 20 D

D is correct. Dalton's atomic model was developed in 1803, Thomson's plum pudding model was proposed in 1900, Rutherford's planetary model was proposed in 1911, and Bohr's shell model was proposed in 1913. **A**, **B** and **C** are incorrect. These options do not list the scientists in chronological order.

SECTION 2

QUESTION 21 (2 marks)

An antiparticle is a subatomic particle that has the same mass as one of the particles of ordinary matter *[1 mark]*
and has an opposite charge to the same particle of ordinary matter. *[1 mark]*

Note: Marks should not be awarded for a response that only mentions an electron and positron, or proton and anti-proton, without the definition above.

QUESTION 22 (5 marks)

Acceleration of the object:

Using Newton's second law, $\sum F_{\text{downhill}} = ma$. As $F_g = mg = 98.0$, $m = 10.0$ kg. *[1 mark]*

$$\sum F = ma$$
$$ma = F_g \times \sin(20.0) - F_f$$
$$10.0a = 98.0 \times \sin(20.0) - 20.0 \quad \textit{[1 mark]}$$
$$10.0a = 33.517 - 20.0$$
$$a = 1.352 \text{ m s}^{-2} \quad \textit{[1 mark]}$$

Distance travelled:

$$s = ut + \frac{1}{2}at^2$$
$$= 0 + \left[\frac{1}{2} \times 1.35 \times 3.0^2\right] \quad \textit{[1 mark]}$$
$$= 6.1 \text{ m} \quad \textit{[1 mark]}$$

QUESTION 23 (4 marks)

The direction of the current is to the right and the external magnetic field is into the page. By the right hand palm rule, the direction of the magnetic force ($nBIl$) acting on the conductor is upwards. *[1 mark]*

Using Newton's second law for the conductor:

$$\sum F = ma$$
$$\text{magnetic force (upwards)} + \text{weight (downwards)} = 0$$
$$nBIl - mg = 0 \quad \textit{[1 mark]}$$
$$m = \frac{nBIl}{g}$$
$$= \frac{1 \times 0.30 \times 2.0 \times 0.50}{9.8} \quad \textit{[1 mark]}$$
$$= 0.03 \text{ kg} \quad \textit{[1 mark]}$$

Note: Formula derived from equating the magnetic force to the weight force when the system is not moving.

QUESTION 24 (5 marks)

$\text{period} = 12\,\text{hours}$

$= 12 \times 60 \times 60$

$= 43\,200 \text{ seconds}$ *[1 mark]*

Using Kepler's third law:

$$\frac{r^3}{T^2} = \frac{GM_{\text{Earth}}}{4\pi^2}$$

$$r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 43\,200^2}{4\pi^2}}$$

[2 marks]

1 mark for correct transposition of equation.

1 mark for correct substitutions.

$= 2.66 \times 10^7 \text{ m}$ *[1 mark]*

$= 2.66 \times 10^4 \text{ km}$ *[1 mark]*

Note: Award the final mark only if it is presented in scientific notation correct to two decimal places.

QUESTION 25 (5 marks)

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$= 1.097 \times 10^7 \left|\left(\frac{1}{5^2} - \frac{1}{2^2}\right)\right|$$ *[1 mark]*

$$= 1.097 \times 10^7 \times \frac{21}{100}$$ *[1 mark]*

$$= 2.30 \times 10^6$$

$$\lambda = \frac{1}{2.30 \times 10^6}$$

$= 4.34 \times 10^{-7} \text{ m}$ *[1 mark]*

$$f = \frac{c}{\lambda}$$

$$= \frac{3.0 \times 10^8}{4.34 \times 10^{-7}}$$ *[1 mark]*

$= 6.9 \times 10^{14} \text{ z}$ *[1 mark]*

QUESTION 26 (4 marks)

The Rutherford model describes the atom as consisting of a small, positive nucleus with the electrons circulating at some distance from the nucleus.

One of the failures of the Rutherford model is that, as the electrons accelerate (in a circle), they should emit energy as light and so should spiral into the nucleus. This does not happen, as matter is stable. *[1 mark]*

The Bohr model explains that electrons occupy particular energy levels such that they have energies corresponding as standing waves that keep them in these energy levels. *[1 mark]*

If the Rutherford model were correct, then as electrons spiral into the nucleus, a continuous range of light frequencies (colours) should be emitted. This did not occur. *[1 mark]*

The Bohr model explains that electrons will only transit between one level and another, absorbing or emitting particular light frequencies that correspond to differences between the energies of the levels. This model agrees with the observations. *[1 mark]*