Neap

Trial Examination 2020

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.		●		

	A	B	C	D
11.	●			
12.		●		
13.			●	
14.		●		
15.	●			
16.			●	
17.	●			
18.			●	
19.				●
20.				●

QUESTION 1 B

$+\frac{2}{3}+\frac{2}{3}-\frac{1}{3}=+1$

Hence *uud* describes a proton.

QUESTION 2 D

The gravitational force has yet to be incorporated into the Standard Model. Because of the scale of particles, the effect of gravity is so weak it is deemed to be negligible.

QUESTION 3 B

$$F_g = mg$$
$$280 = 70 \times g$$
$$g = 4.0 \text{ m s}^{-2}$$

QUESTION 4 B

Since $F = \frac{Gm_1m_2}{r^2}$, if the distance between the masses increases by a factor of 3, this would increase the force by $\frac{1}{3^2}$, or $\frac{1}{9}$. If the magnitude of one mass is tripled, this will increase the force by a factor of 3. Hence overall the new force is $\frac{1}{3}F$.

QUESTION 5 B

$$F = \frac{kQ_1Q_2}{r^2}$$
$$= \frac{9.0 \times 10^9 \times 1.0 \times 10^{-6} \times 2.0 \times 10^{-6}}{(0.01)^2}$$
$$= 180 \text{ N right}$$

QUESTION 6 D

A car's frame of reference when it is travelling at a constant speed around a corner is not an example of an inertial frame of reference.

A car travelling at a constant speed around a corner is accelerating. It has a non-zero net force acting on it that is providing the centre-seeking force for circular motion.

QUESTION 7 C

An electron (e^-) and a positron (e^+) annihilate when they interact. Thus **C** would annihilate an electron and produce electromagnetic radiation.

QUESTION 8 A

Electrons that collide scatter in various directions. The left-hand side of the diagram shows electrons approaching. The lines on the left are getting closer together as time passes. The repulsion between the electrons gets stronger. They exchange and a photon is created. The photon exists and acts between them as long as the interaction takes place. Afterwards they move away from each other with different velocities (magnitude and direction), as seen on the right-hand side of the diagram.

QUESTION 9 B

Use the right-hand rule or a similar hand rule. The direction is then reversed because it is a negatively charged particle ($-q$).

QUESTION 10 B

Length has contracted, so the observed length of the ruler is now 0.80 m.

$$l = \frac{l_o}{\gamma}$$

$$\gamma = \frac{1.00}{0.20}$$

$$= 1.25$$

$$v = c\sqrt{1 - \frac{1}{\gamma^2}}$$

$$= c\sqrt{1 - \frac{1}{1.25^2}}$$

$$= 0.60c$$

QUESTION 11 A

Inertia is a property of an object, not a force. The other options are incorrect.

QUESTION 12 B

The constant force means that $F_N = 0$ N.

$$F_D - 1.2 = 0$$

$$F_D = 1.2 \text{ kN}$$

QUESTION 13 C

$$F = \frac{m4\pi^2 r}{T^2}$$

$$= \frac{0.40 \times 4\pi^2 2.0}{(0.40)^2}$$

$$= 2.0 \times 10^2 \text{ N}$$

QUESTION 14 B

$$F_{net} = ma$$

$$1 \times 9.8 = (1.0 + 2.0)a$$

$$a = 3.3 \text{ m s}^{-2}$$

$$T = 2.0 \times 3.3$$

$$= 6.5 \text{ N}$$

QUESTION 15 A

The electric field strength of a proton is approximately 1.0×10^{28} the gravitational field strength and is opposite in direction. The electric field is radially outwards. The gravitational field is radially inwards.

QUESTION 16 C

$$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

$$= \sqrt[3]{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (2 \times 60 \times 60)^2}{4\pi^2}}$$

$$= 8.06 \times 10^6 \text{ m}$$

$$\text{height above Earth} = 8.06 \times 10^6 - 6.37 \times 10^6$$

$$= 1.7 \times 10^6 \text{ m}$$

QUESTION 17 A

The voltage is stepped up, so it is a step up transformer.

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$\frac{8}{32} = \frac{80}{n_s}$$

$$n_s = 320$$

QUESTION 18 C

700 nm is in the red region of the visible light spectrum.

$$c = f\lambda$$

$$3.0 \times 10^8 = f \times (700 \times 10^{-9})$$

$$f = 4.29 \times 10^{14} \text{ Hz}$$

QUESTION 19 D

Part of the emission spectrum produces a photon of energy 12.1 – 10.2 = 1.9 eV. The only answer option that includes 1.9 eV is **D**.

QUESTION 20 D

The direction of the magnetic field is clockwise. Using the right hand grip rule, the thumb is into the page and the fingers curl in a clockwise direction.

Section 2

QUESTION 21 (2 marks)

Mesons are a type of hadron. *[1 mark]*

They consist of a quark and an antiquark. *[1 mark]*

QUESTION 22 (3 marks)

Thomson's model had a large amorphous positive charge with embedded point electrons. *[1 mark]*
Rutherford's model had a small dense positive nucleus and electrons outside the nucleus filling atomic space. *[1 mark]*

When fired at a a thin gold leaf, alpha particles mostly pass through the leaf, and some are reflected backwards. This indicates that the atom is mainly space with a central positive nucleus, supporting Rutherford's model. *[1 mark]*

QUESTION 23 (3 marks)

The neutron was last to be discovered. *[1 mark]*
This is because the detection of the proton and electron relied on their charge, *[1 mark]*
but neutrons have no charge. *[1 mark]*

QUESTION 24 (8 marks)

Observation 1: Threshold frequency

By varying the frequency, f, of incident light for a particular metal, there is a frequency below which no photoelectrons are observed. This frequency is called threshold frequency, f_o, where if $f > f_o$, photoelectrons are emitted, while if $f < f_o$, no photoelectrons are emitted. If $f > f_o$, the rate at which photoelectrons are produced varies proportionally with intensity, I, while if $f < f_o$, no photoelectrons are emitted no matter how intense the light is. The wave model predicted that any frequency of light, as long as it was intense enough and was shone for long enough, would liberate photoelectrons.

Observation 2: Maximum kinetic energy of the photoelectrons is dependent on frequency, and not on the intensity of the light.
Increasing intensity of light causes an increase in the current because more photons of light mean more electrons liberated (1–1 interaction). Increasing the intensity of light does not cause a change in the maximum kinetic energy of the photoelectrons. Increasing intensity has no effect on the stopping voltage. The wave model predicted a higher intensity light would liberate photoelectrons with higher kinetic energies and hence require a greater stopping voltage.

[8 marks]
1 mark for each correct observation.
1 mark for each correct outline.
1 mark for each explanation of how the observation supports the particle model of light.
1 mark for each observation that the wave model would have predicted.

QUESTION 25 (2 marks)

According to the relativity of simultaneity, events that are simultaneous in one frame of reference are not necessarily simultaneous in another frame of reference, *[1 mark]*
even if both frames are inertial. *[1 mark]*

QUESTION 26 (4 marks)

The bright and dark bands are due to interference between the two sources of light, which are created as the laser travels and diffracts through the two narrow slits. *[1 mark]*
When the path difference between the slits is an integer multiple of the wavelength, constructive interference results and a bright band is formed (maximum-intensity antinode). *[1 mark]*
When the path difference between the slits is a half-integer multiple (for example, 0.5λ, 1.5λ, …) of the wavelength, destructive interference results and a dark band is formed (minimum-intensity node). *[1 mark]*
Diffraction, interference and superposition are all wave-only in nature. *[1 mark]*

QUESTION 27 (3 marks)

$$F_{\text{net}} = ma$$

$$mg\sin\theta - f = ma$$ *[1 mark]*

$$100.0 \times 9.8\sin 25.0 - 140.0 = 100.0a$$ *[1 mark]*

$$a = 2.7 \text{ m s}^{-2}$$ *[1 mark]*