SQP Am

7. The photoelectric effect

A is evidence for the wave nature of light

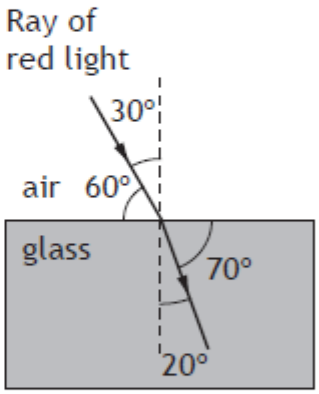
B can be observed using a diffraction grating

C can only be observed with ultra-violet light

D can only be observed with infra-red light

E is evidence for the particulate nature of light.

8. A ray of red light is incident on a glass block as shown.



The refractive index of the glass for this light is

A 0·53

B 0·68

C 1·46

D 1·50

E 2·53.

9. A ray of red light travels from air into water.

Which row in the table describes the change, if any, in speed and frequency of a ray of red light as it travels from air into water?

	Speed	*Frequency*
A	increases	increases
B	increases	stays constant
C	decreases	stays constant
D	decreases	decreases
E	stays constant	decreases

10. Light from a point source is incident on a screen. The screen is 3·0 m from the source.

The irradiance at the screen is 8·0 W m^{-2}.

The light source is now moved to a distance of 12 m from the screen.

The irradiance at the screen is now

A 0·50 W m^{-2}

B 1·0 W m^{-2}

C 2·0 W m^{-2}

D 4·0 W m^{-2}

E 8·0 W m^{-2}.

11. A student makes the following statements about an electron.

I An electron is a boson.

II An electron is a lepton.

III An electron is a fermion.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

12. Radiation of frequency $9{\cdot}40 \times 10^{14}$Hz is incident on a clean metal surface.

The work function of the metal is $3{\cdot}78 \times 10^{-19}$J.

The maximum kinetic energy of an emitted photoelectron is

A $2{\cdot}45 \times 10^{-19}$J

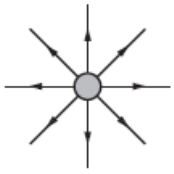
B $3{\cdot}78 \times 10^{-19}$J

C $6{\cdot}23 \times 10^{-19}$J

D $1{\cdot}00 \times 10^{-18}$J

E $2{\cdot}49 \times 10^{33}$J.

13. The diagram represents the electric field around a single point charge.



A student makes the following statements about this diagram.

I The separation of the field lines indicates the strength of the field.

II The arrows on the field lines indicate the direction in which an electron would move if placed in the field.

III The point charge is positive.

Which of these statements is/are correct?

A I only

B II only

C I and III only

D II and III only

E I, II and III

7. Protons and neutrons are composed of combinations of up and down quarks.
Up quarks have a charge of $+\frac{2}{3}e$ while down quarks have a charge of $-\frac{1}{3}e$.

(a) (i) Determine the combination of up and down quarks that makes up:

(A) a proton; 1

(B) a neutron. 1

(ii) Name the boson that is the mediating particle for the strong force. 1

(b) A neutron decays into a proton, an electron and an antineutrino.

$$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e + \overline{\nu}$$

Name of this type of decay. 1

9. (a) The following statement represents a fusion reaction.

$$4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}He + 2\,{}^{0}_{1}e^{+}$$

The masses of the particles involved in the reaction are shown in the table.

Particle	*Mass* (kg)
$^{1}_{1}H$	$1{\cdot}673 \times 10^{-27}$
$^{4}_{2}He$	$6{\cdot}646 \times 10^{-27}$
$^{0}_{1}e$	negligible

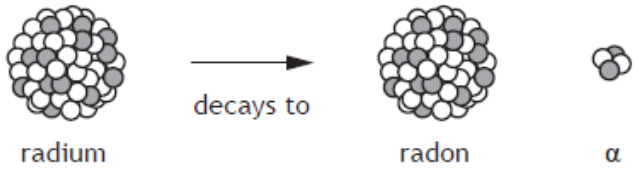
(i) Calculate the energy released in this reaction. 4

(ii) Calculate the energy released when 0·20 kg of hydrogen is converted to helium by this reaction. 3

(iii) Fusion reactors are being developed that use this type of reaction as an energy source.

Explain why this type of fusion reaction is hard to sustain in these reactors. **1**

(b) A nucleus of radium-224 decays to radon by emitting an alpha particle.



The masses of the particles involved in the decay are shown in the table.

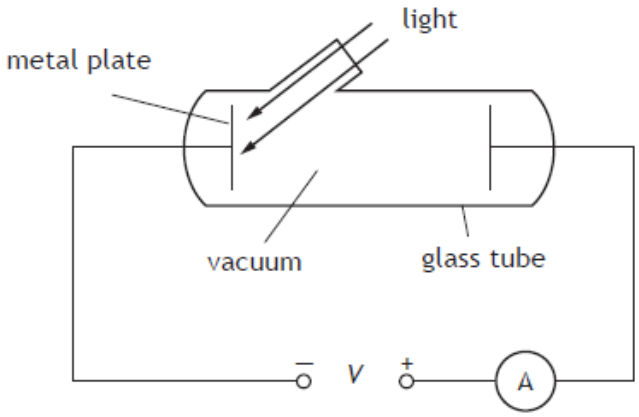
Particle	*Mass* (kg)
radium-224	$3{\cdot}720 \times 10^{-25}$
radon-220	$3{\cdot}653 \times 10^{-25}$
alpha	$6{\cdot}645 \times 10^{-27}$

Before the decay the radium-224 nucleus is at rest.

After the decay the alpha particle moves off with a velocity of $1{\cdot}460 \times 10^{7}\,\text{m s}^{-1}$.

Calculate the velocity of the radon-220 nucleus after the decay. **3**

10. The diagram shows equipment used to investigate the photoelectric effect.



(a) When blue light is shone on the metal plate there is a current in the circuit. When blue light is replaced by red light there is no current.

Explain why this happens. **2**

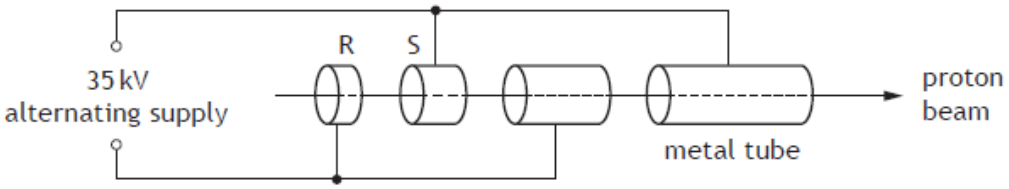
(b) The blue light has a frequency of $7{\cdot}0 \times 10^{14}$ Hz.

The work function for the metal plate is $2{\cdot}0 \times 10^{-19}$ J.

Calculate the maximum kinetic energy of the electrons emitted from the plate by this light. **3**

8. A linear accelerator is used to accelerate protons.

The accelerator consists of hollow metal tubes placed in a vacuum.



The diagram shows the path of protons through the accelerator.

Protons are accelerated across the gaps between the tubes by a potential difference of 35 kV.

(a) The protons are travelling at $1{\cdot}2 \times 10^{6}$ m s^{-1} at point **R**.

(i) Show that the work done on a proton as it accelerates from **R** to **S** is $5{\cdot}6 \times 10^{-15}$ J. **2**

Space for working and answer

(ii) Calculate the speed of the proton as it reaches **S**. **5**

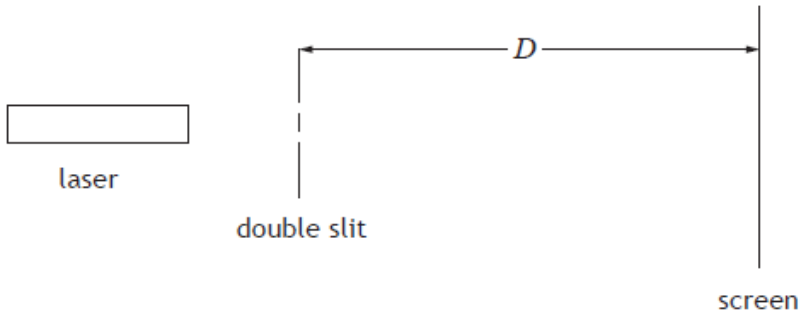
Space for working and answer

(b) Suggest one reason why the lengths of the tubes increase along the accelerator. **1**

11. A helium-neon laser produces a beam of coherent red light.

(a) State what is meant by *coherent light*. **1**

(b) A student directs this laser beam onto a double slit arrangement as shown in the diagram.



A pattern of bright red fringes is observed on the screen.

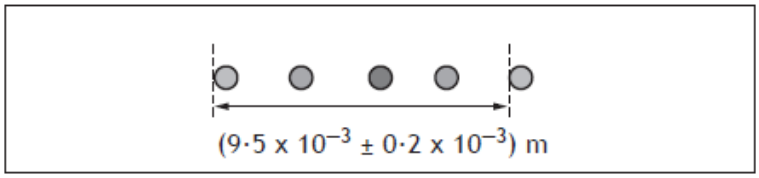
(i) Explain, in terms of waves, why bright red fringes are produced. **1**

(ii) The average separation, Δx, between adjacent fringes is given by the relationship

$$\Delta x = \frac{\lambda D}{d}$$

where: λ is the wavelength of the light
D is the distance between the double slit and the screen
d is the distance between the two slits

The diagram shows the value measured by the student of the distance between a series of fringes and the uncertainty in this measurement.



The student measures the distance, D, between the double slit and the screen as $(0{\cdot}750 \pm 0{\cdot}001)$ m.

Calculate the best estimate of the distance between the two slits.

An uncertainty in the calculated value is not required. **4**

(iii) The student wishes to determine more precisely the value of the distance between the two slits d.

Show, by calculation, which of the student's measurements should be taken more precisely in order to achieve this.

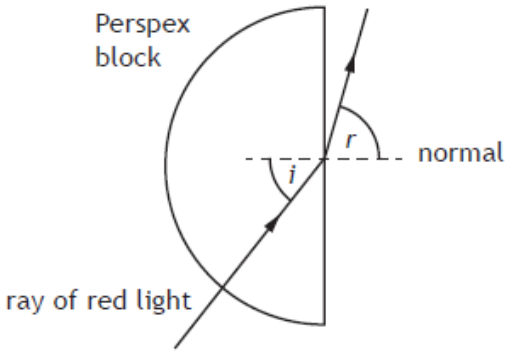
You must indicate clearly which measurement you have identified. **3**

(iv) The helium-neon laser is replaced by a laser emitting green light. No other changes are made to the experimental set-up.

Explain the effect this change has on the separation of the fringes observed on the screen. **2**

12. A student is investigating the refractive index of a Perspex block for red light.

The student directs a ray of red light towards a semicircular Perspex block as shown.



The angle of incidence i is then varied and the angle of refraction r is measured using a protractor.

The following results are obtained.

i (°)	r (°)	$\sin i$	$\sin r$
10	16	0·17	0·28
15	25	0·26	0·42
20	32	0·34	0·53
25	37	0·42	0·60
30	53	0·50	0·80

(a) (i) Using square ruled paper, draw a graph to show how sin r varies with sin i. **3**

(ii) Use the graph to determine the refractive index of the Perspex for this light. **2**

(iii) Suggest **two** ways in which the experimental procedure could be improved to obtain a more accurate value for the refractive index. **2**

(b) The Perspex block is replaced by an identical glass block with a refractive index of 1·54 and the experiment is repeated.

Determine the maximum angle of incidence that would produce a refracted ray. **3**