AQA – Particles and radiation – A2 Physics P1

1. June/2021/Paper_7408_01/No. 01

0 1 Cosmic rays are high-energy particles that come from space. Most of these particles are protons. There are other particles in cosmic rays, including atomic nuclei.

Table 1 gives the data for one particular nucleus **X**.

Table 1

Mass / kg	8.02×10^{-26}
Specific charge / C kg^{-1}	4.39×10^{7}
Kinetic energy / MeV	215

0 1 . 1 Determine the number of neutrons in nucleus **X**.

[3 marks]

number of neutrons = _____

0 1 . 2 Calculate the speed of **X**.
Ignore relativistic effects.

[3 marks]

speed = _____ m s^{-1}

A pion (π^+) and a kaon (K^+) are produced when cosmic rays interact with the upper atmosphere.

0 1 . 3 The π^+ decays to produce a positron and an electron neutrino.

Show how the conservation laws apply to this decay.

[2 marks]

0 1 . 4 The K^+ decays to produce an anti-muon and a muon neutrino.

Explain how strangeness applies in this decay.

[2 marks]

0 1 . 5 Write an equation for a K^+ decay that involves only hadrons.

[2 marks]

2. June/2021/Paper_7408_01/No. 09

The gravitational force is one of the four fundamental forces.
The ticks in the table match particles with the other fundamental forces.

In which row is the particle matched to the only other fundamental forces it experiences?

[1 mark]

	Particle	Electromagnetic force	Weak nuclear force	Strong nuclear force	
A	μ^+	✓	✓		⬭
B	$\overline{p}$	✓		✓	⬭
C	π^0	✓	✓	✓	⬭
D	ν_e		✓	✓	⬭

3. June/2021/Paper_7408_01/No. 10

The proton number of uranium is 92 and the proton number of radon is 88

Which series of decays turns a uranium nucleus into a radon nucleus?

[1 mark]

A $\alpha + \beta^- + \beta^- + \alpha + \alpha$ ⬭

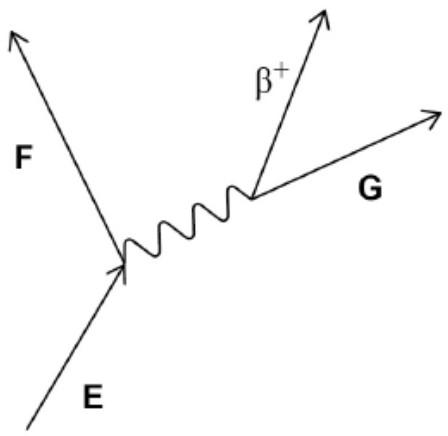
B $\beta^- + \beta^- + \alpha + \beta^- + \alpha$ ⬭

C $\alpha + \alpha + \alpha + \alpha + \beta^-$ ⬭

D $\beta^- + \beta^- + \beta^- + \beta^- + \alpha$ ⬭

4. June/2021/Paper_7408_01/No. 11

The diagram represents a particle interaction.



Which row identifies particles **E**, **F** and **G**?

[1 mark]

	E	F	G	
A	up quark	down quark	neutrino	⬭
B	down quark	up quark	neutrino	⬭
C	up quark	down quark	antineutrino	⬭
D	down quark	up quark	antineutrino	⬭

5. June/2021/Paper_7408_01/No. 12

The quark combination of a particle is $s\bar{u}$.

Which is true for this particle?

[1 mark]

A It has a baryon number of 1 ⬭

B It has a charge of -1.6×10^{-19} C. ⬭

C It is a pion. ⬭

D It has a strangeness of $-\frac{1}{3}$ ⬭

6. June/2021/Paper_7408_01/No. 13

Monochromatic light with a photon energy of 4.1×10^{-19} J is incident on a metal surface. The maximum speed of the photoelectrons released is 4.2×10^{5} m s^{-1}.

What is the work function of the metal?

[1 mark]

A 2.5×10^{-19} J ⬭

B 3.3×10^{-19} J ⬭

C 4.1×10^{-19} J ⬭

D 4.9×10^{-19} J ⬭

7. June/2021/Paper_7408_01/No. 14

What is the role of the mercury vapour in a fluorescent tube?

[1 mark]

A It absorbs photons of UV light and emits visible light. ⬭

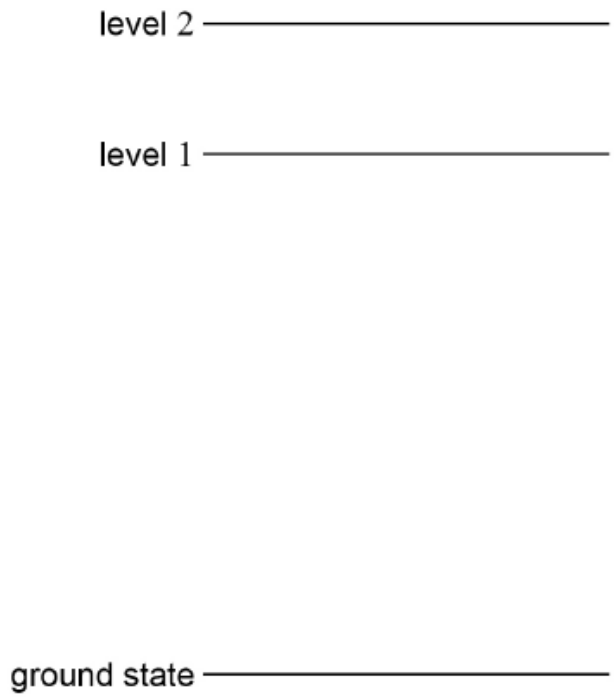
B It absorbs photons of visible light and emits UV light. ⬭

C It emits photons of visible light following ionisation or excitation. ⬭

D It emits photons of UV light following ionisation or excitation. ⬭

8. June/2021/Paper_7408_01/No. 15

The diagram shows the three lowest energy levels for an atom.
The energy levels have been drawn to scale.



Transitions of electrons between these energy levels produce photons of the following frequencies:

4.56×10^{14} Hz
2.46×10^{15} Hz
2.92×10^{15} Hz.

What is the difference in energy between the ground state and energy level 1?

[1 mark]

A 0.3×10^{-18} J ⬭

B 1.3×10^{-18} J ⬭

C 1.6×10^{-18} J ⬭

D 1.9×10^{-18} J ⬭

9. June/2021/Paper_7408_01/No. 16

A muon and an electron are travelling at the same speed.

Which row gives the particle with the greater kinetic energy and the particle with the longer de Broglie wavelength?

[1 mark]

	Greater kinetic energy	Longer de Broglie wavelength	
A	muon	muon	⬭
B	muon	electron	⬭
C	electron	muon	⬭
D	electron	electron	⬭

10. June/2020/Paper_7408_01/No. 01

0 1 . 1 Determine whether the following reaction is a possible decay for the neutral pion π^0.

$$\pi^0 \rightarrow e^- + \mu^+ + \bar{\nu}_e$$

[2 marks]

0 1 . 2 State the **two** possible quark configurations of a π^0.

[1 mark]

1 _____

2 _____

0 1 . 3 A student suggests that the kaon K^0 and the anti-kaon $\overline{K^0}$ are the same particle.

Discuss whether this suggestion is correct.

[2 marks]

0 1 . 4 The nucleus is held together by a force. It was predicted that a particle exists that is responsible for this force. The particle itself must experience this force.

The particle would have a rest energy between that of an electron and half that of a nucleon.

Discuss whether a kaon, a muon and a pion **each** have the properties of the predicted particle.

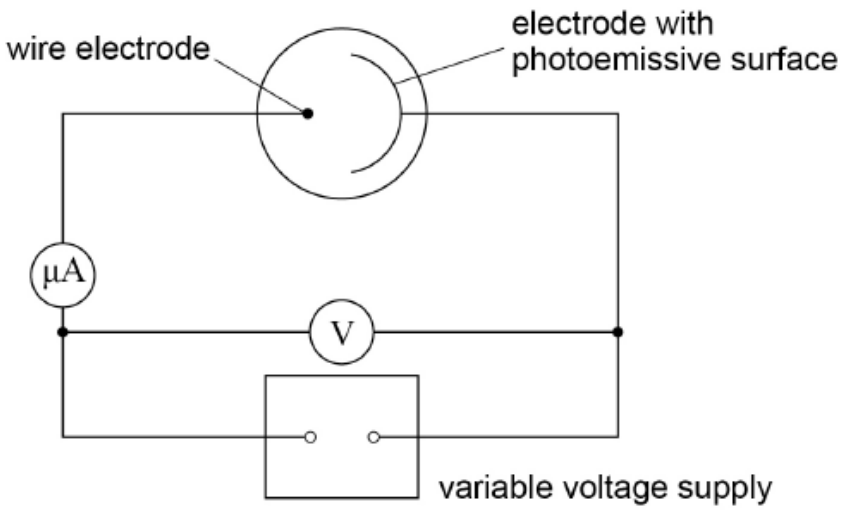
Information about these three particles is in the Data and Formulae Booklet.

[4 marks]

11. June/2020/Paper_7408_01/No. 02

Figure 1 shows an arrangement used to investigate the photoelectric effect.

Figure 1



A current is measured on the microammeter only when electromagnetic radiation with a frequency greater than a certain value is incident on the photoemissive surface.

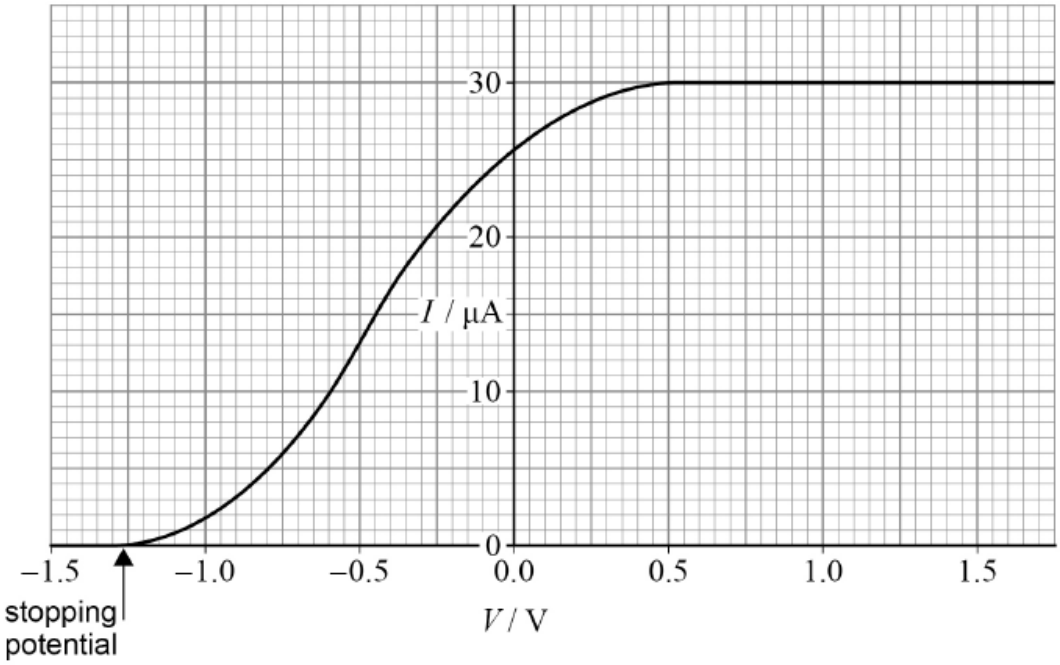
0 2 . 1 Explain why the frequency of the electromagnetic radiation must be greater than a certain value.

[2 marks]

The apparatus in **Figure 1** is used with a monochromatic light source of constant intensity. Measurements are made to investigate how the current I in the microammeter varies with positive and negative values of the potential difference V of the variable voltage supply.

Figure 2 shows how the results of the investigation can be used to find the stopping potential.

Figure 2



0 2 . 2 Determine the number of photoelectrons per second leaving the photoemissive surface when the current is a maximum.

[2 marks]

number of photoelectrons per second = _____

0 2 . 3 Explain why I reaches a constant value for positive values of V.

[2 marks]

0 2 . 4 Explain why I decreases as the value of V becomes more negative.

[3 marks]

0 2 . 5 The investigation is repeated with a different photoemissive surface that has a smaller value of the work function. The source of electromagnetic radiation is unchanged.

Discuss the effect that this change in surface has on the value of the stopping potential.

[3 marks]

12. June/2020/Paper_7408_01/No. 08

A photon has energy of 1×10^{18} eV.
An object of mass 0.03 kg has kinetic energy equal to the energy of the photon.

What is the speed of the object?

[1 mark]

A 1 m s^{-1} ⬭

B 3 m s^{-1} ⬭

C 10 m s^{-1} ⬭

D 30 m s^{-1} ⬭

13. June/2020/Paper_7408_01/No. 09

A deuterium nucleus and a tritium nucleus fuse together to produce a helium nucleus and particle **X**.

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + \mathbf{X}$$

What is **X**?

[1 mark]

A an electron ⬭

B a neutron ⬭

C a positron ⬭

D a proton ⬭

14. June/2020/Paper_7408_01/No. 10

The radioactive nuclide $^{232}_{90}\mathrm{Th}$ decays by one α emission followed by two β^- emissions.

Which nuclide is formed as a result of these decays?

[1 mark]

A $^{238}_{92}\mathrm{U}$ ⬭

B $^{230}_{90}\mathrm{Th}$ ⬭

C $^{228}_{90}\mathrm{Th}$ ⬭

D $^{228}_{88}\mathrm{Rn}$ ⬭

15. June/2020/Paper_7408_01/No. 12

An electron collides with an isolated atom and raises an atomic electron to a higher energy level.

Which statement is correct?

[1 mark]

A The colliding electron is captured by the nucleus of the atom. ⬭

B A photon is emitted when the electron rises to the higher energy level. ⬭

C An electron is emitted when the excited electron returns to the ground state. ⬭

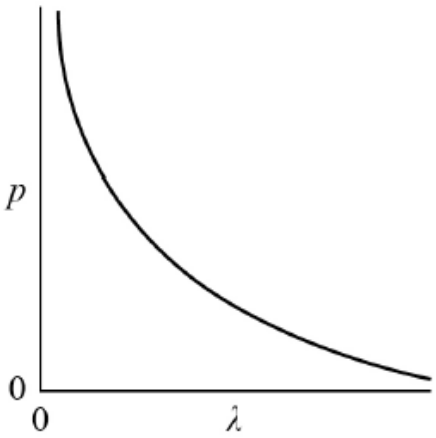
D The colliding electron transfers energy to the atomic electron. ⬭

16. June/2020/Paper_7408_01/No. 13

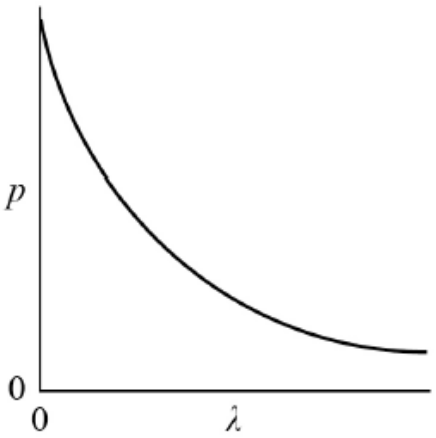
Which graph shows the variation of momentum p with wavelength λ of a photon?

[1 mark]

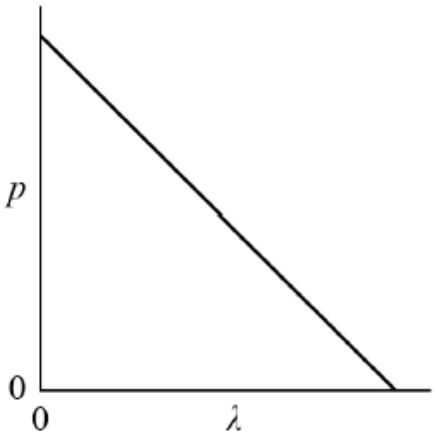
A



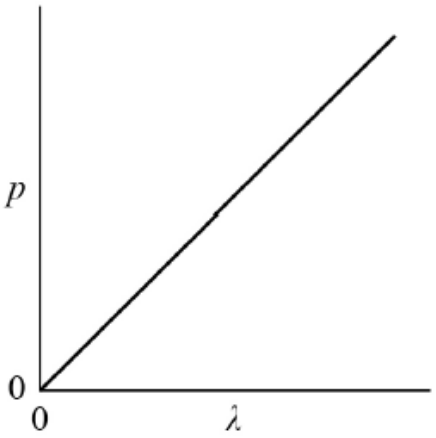
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭