

1

Which of the following nuclei has the smallest specific charge?

A ${}^1_1\text{H}$ ☐

B ${}^{12}_6\text{C}$ ☐

C ${}^{14}_6\text{C}$ ☐

D ${}^{235}_{92}\text{U}$ ☐

(Total 1 mark)

2

${}^{232}_{90}\text{Th}$ is an unstable nuclide in a radioactive decay series. It decays by emitting an α particle. The next two nuclides in the series emit β^- particles.

What nuclide is formed after these three decays have taken place?

A ${}^{230}_{90}\text{Th}$ ☐

B ${}^{228}_{92}\text{U}$ ☐

C ${}^{228}_{88}\text{Ra}$ ☐

D ${}^{228}_{90}\text{Th}$ ☐

(Total 1 mark)

3

Which line does **not** give the correct exchange particle for the process?

	Process	Exchange particle	
A	gravitational attraction	W boson	☐
B	electrostatic repulsion of electrons	virtual photon	☐
C	strong interaction	pion	☐
D	β^- decay	W boson	☐

(Total 1 mark)

4

In an experiment to demonstrate the photoelectric effect, a charged metal plate is illuminated with light from different sources. The plate loses its charge when an ultraviolet light source is used but not when a red light source is used.

What is the reason for this?

- A The intensity of the red light is too low. ☐
- B The wavelength of the red light is too short. ☐
- C The frequency of the red light is too high. ☐
- D The energy of red light photons is too small. ☐

(Total 1 mark)

5

Which of the following classes of electromagnetic waves will **not** ionise neutral atoms?

What is the reason for this?

- A ultraviolet ☐
- B X radiation ☐
- C gamma radiation ☐
- D microwave ☐

(Total 1 mark)

6

Experiments on which of the following suggested the wave nature of electrons?

- A electron diffraction by a crystalline material ☐
- B β^- decay ☐
- C line spectra of atoms ☐
- D the photoelectric effect ☐

(Total 1 mark)

7

What are the numbers of hadrons, baryons and mesons in an atom of ${}^7_3\text{Li}$?

	hadrons	baryons	mesons	
A	7	3	3	☐
B	7	4	4	☐
C	7	7	0	☐
D	10	7	0	☐

(Total 1 mark)

8

A calcium ion is formed by removing two electrons from an atom of ${}^{40}_{20}\text{Ca}$. What is the specific charge of the calcium ion?

- A $3.2 \times 10^{-19} \text{ C kg}^{-1}$ ☐
- B $2.9 \times 10^{-18} \text{ C kg}^{-1}$ ☐
- C $4.8 \times 10^6 \text{ C kg}^{-1}$ ☐
- D $4.8 \times 10^7 \text{ C kg}^{-1}$ ☐

(Total 1 mark)

9

Electrons and protons in two beams are travelling at the same speed. The beams are diffracted by objects of the same size.

Which correctly compares the de Broglie wavelength λ_e of the electrons with the de Broglie wavelength λ_p of the protons and the width of the diffraction patterns that are produced by these beams?

	comparison of de Broglie wavelength	diffraction pattern	
A	$\lambda_e > \lambda_p$	electron beam width > proton beam width	☐
B	$\lambda_e < \lambda_p$	electron beam width > proton beam width	☐
C	$\lambda_e > \lambda_p$	electron beam width < proton beam width	☐
D	$\lambda_e < \lambda_p$	electron beam width < proton beam width	☐

(Total 1 mark)

10

Which of the following is **not** true?

- A** Each meson consists of a single quark and a single antiquark.
- B** Each baryon consists of three quarks.
- C** The magnitude of the charge on every quark is $\frac{1}{3}$
- D** A particle consisting of a single quark has not been observed.

☐☐☐☐

(Total 1 mark)

11

The intensity of a monochromatic light source is increased. Which of the following is correct?

	Energy of an emitted photon	Number of photons emitted per second	
A	increases	increases	☐
B	increases	unchanged	☐
C	unchanged	increases	☐
D	unchanged	unchanged	☐

(Total 1 mark)

12

The nucleus of ${}^9_4\text{Be}$ captures a proton and emits an α particle. What is the product nucleus?**A** ${}^{10}_6\text{C}$ ☐**B** ${}^7_3\text{Li}$ ☐**C** ${}^6_3\text{Li}$ ☐**D** ${}^6_2\text{He}$ ☐

(Total 1 mark)

13

Monochromatic radiation from a source of light (source A) is shone on to a metallic surface and electrons are emitted from the surface. When a second source (source B) is used no electrons are emitted from the metallic surface. Which property of the radiation from source A must be greater than that from source B?

- A amplitude ☐
- B frequency ☐
- C intensity ☐
- D wavelength ☐

(Total 1 mark)

14

An electron has a kinetic energy E and a de Broglie wavelength λ . The kinetic energy is increased to $4E$. What is the new de Broglie wavelength?

- A $\frac{\lambda}{4}$ ☐
- B $\frac{\lambda}{2}$ ☐
- C λ ☐
- D 4λ ☐

(Total 1 mark)

15

Which line correctly classifies the particle shown?

	Particle	Category	Quark combination	
A	neutron	baryon	$\bar{u}d$	☐
B	neutron	meson	udd	☐
C	proton	baryon	uud	☐
D	positive pion	meson	$\bar{u}d$	☐

(Total 1 mark)

16

In a photoelectric experiment, light is incident on the metal surface of a photocell. Increasing the intensity of the illumination at the surface leads to an increase in the

A work function

☐

B minimum frequency at which electrons are emitted

☐

C current through the photocell

☐

D speed of the electrons

☐

(Total 1 mark)

17

An electron collides with a neutral atom and ionizes it. Which of the following describes the particles present after the collision?

A An electron and an excited atom.

☐

B An excited atom containing an excess electron.

☐

C Two electrons and a positive ion.

☐

D Two electrons and a neutral atom in the ground state.

☐

(Total 1 mark)

18

A radioactive nucleus emits a β^- particle then an α particle and finally another β^- particle. The final nuclide is

A an isotope of the original element

☐

B the same element with a different proton number

☐

C a new element of higher proton number

☐

D a new element of lower nucleon number

☐

(Total 1 mark)

19

Which equation shows the process of annihilation?

A $\pi^- + \pi \rightarrow \gamma$

☐

B $p + \bar{p} \rightarrow \gamma + \gamma$

☐

C $\beta^- + p \rightarrow \gamma$

☐

D $\gamma + \gamma \rightarrow \beta^+ + \beta^-$

☐

(Total 1 mark)

20

Which of the following is **not** made of quarks?

A kaon

☐

B muon

☐

C neutron

☐

D pion

☐

(Total 1 mark)

21

A proton moving with a speed v has a de Broglie wavelength λ .What is the de Broglie wavelength of an alpha particle moving at the same speed v ?

A $\frac{\lambda}{4}$

☐

B λ

☐

C 2λ

☐

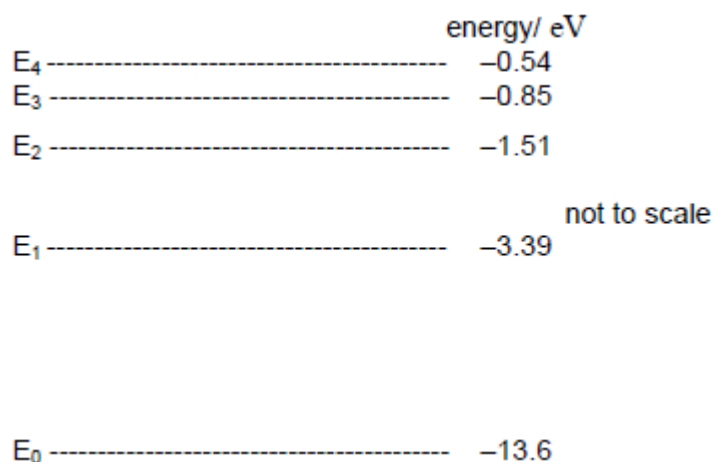
D 4λ

☐

(Total 1 mark)

22

The diagram gives some of the energy levels of a hydrogen atom.



The transition of an excited hydrogen atom from E_3 to E_1 causes a photon of visible light to be emitted.

Which transition causes a photon of ultraviolet light to be emitted?

- | | | |
|----------|----------------|--------------------------|
| A | E_4 to E_3 | ☐ |
| B | E_3 to E_2 | ☐ |
| C | E_2 to E_1 | ☐ |
| D | E_1 to E_0 | ☐ |

(Total 1 mark)

23

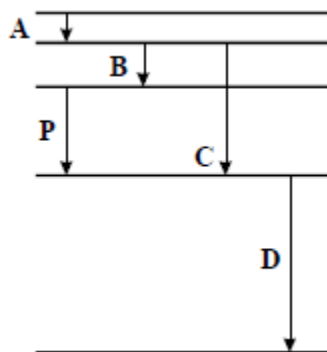
In a nuclear reaction $^{14}_7\text{N}$ is bombarded by neutrons. This results in the capture of one neutron and the emission of one proton by one nucleus of $^{14}_7\text{N}$. The resulting nucleus is

- A** $^{13}_7\text{N}$
- B** $^{14}_6\text{C}$
- C** $^{12}_6\text{C}$
- D** $^{14}_8\text{O}$

(Total 1 mark)

24

The diagram **drawn to scale** shows some of the energy levels of an atom. Transition **P** results in the emission of a photon of wavelength $4 \times 10^{-7} \text{ m}$.

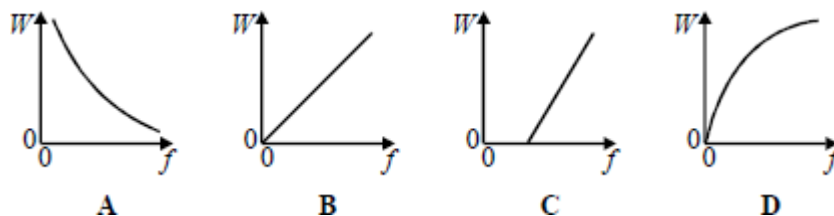


Which one of the transitions **A**, **B**, **C**, or **D** could result in the emission of a photon of wavelength $8 \times 10^{-7} \text{ m}$?

(Total 1 mark)

25

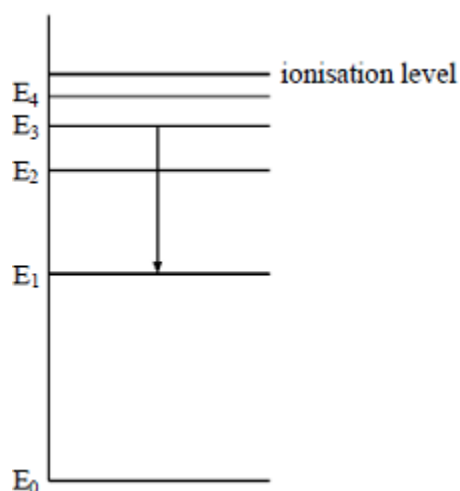
Which one of the graphs best represents the relationship between the energy W of a photon and the frequency f of the radiation?



(Total 1 mark)

26

The diagram shows some energy levels of an atom.



The transition E_3 to E_1 corresponds to the emission of visible light.

A transition corresponding to the emission of infrared radiation could be

- A E_1 to E_0
- B E_4 to E_1
- C E_1 to E_2
- D E_3 to E_2

(Total 1 mark)

27

Which of the following statements about muons is **incorrect**?

- A A muon is a lepton. ☐
- B A muon has a greater mass than an electron. ☐
- C If a muon and an electron each have the same de Broglie wavelength then they each have the same momentum. ☐
- D A muon with the same momentum as an electron has a larger kinetic energy than the electron. ☐

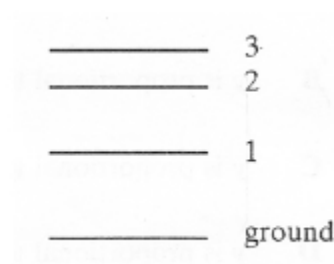
(Total 1 mark)

28

The values of the lowest three energy levels in a particular atom are shown in the table.

The diagram shows these levels together with the ground state of the atom.

Level	Energy/eV
3	-0.85
2	-1.51
1	-3.39



When an electron moves from level 3 to level 1, radiation of frequency 6.2×10^{14} Hz is emitted.

What is the frequency of the radiation emitted when an electron moves from level 2 to level 1?

- A** 2.3×10^{14} Hz ☐
- B** 3.5×10^{14} Hz ☐
- C** 4.6×10^{14} Hz ☐
- D** 8.3×10^{14} Hz ☐

(Total 1 mark)

29

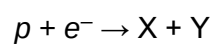
What is the best estimate for the order of magnitude for the diameter of an atom?

- A** 10^{-14} m ☐
- B** 10^{-12} m ☐
- C** 10^{-11} m ☐
- D** 10^{-8} m ☐

(Total 1 mark)

30

Electron capture can be represented by the following equation.



Which row correctly identifies **X** and **Y**?

	X	Y	
A	p	K ⁻	☐
B	e ⁻	e ⁺	☐
C	n	V _e	☐
D	n	π ⁰	☐

(Total 1 mark)