Measurements and theirs errors – A2 Physics P1

1. June/2024/Paper_7408/1/No.1

0 1 . 1 State the names of the four fundamental interactions.

[1 mark]

1 Gravity

2 Weak Nuclear

3 Electromagnetic

4 Strong nuclear

0 1 . 2 State the products of the decay of a free neutron.

[1 mark]

proton and electron

0 1 . 3 Explain which of the fundamental interactions is responsible for the decay of the neutron.

[2 marks]

Weak interaction. when neutron turns into proton and this happens when it changes into quark

0 1 . 4 The forces between two moving electrons cause their paths to change.

Explain, using the concept of exchange particles, why the electron paths change.

[3 marks]

Electrons are leptons and when they interact, they exchange their particles (virtual protons). Since they have momentum and upon exchange, the momentum of both electrons is also changed

2. June/2024/Paper_7408/1/No.2

0 2 A positive pion collides with a neutron and the following interaction is observed:

$$\pi^{+} + n \rightarrow K^{+} + \Sigma^{0}$$

Σ^{0} is a neutral sigma particle with a strangeness of -1

The interaction can be used to deduce the classifications of the Σ^{0}.

0 2 . 1 Identify the classifications of each particle in **Table 1**.
Tick (✓) the appropriate boxes for each particle.

[2 marks]

Table 1

Particle	Baryon	Hadron	Lepton	Meson
π^{+}		✓		✓
n	✓	✓		
K^{+}		✓		✓
Σ^{0}	✓	✓		

0 2 . 2 A conservation rule predicts that the following interaction **cannot** occur:

$$\pi^{-} + n \rightarrow K^{-} + \Sigma^{0}$$

Baryon ⇒ 0+1 → 0+1 (Conserved)
Charge ⇒ −1+0 → −1+0 (Conserved)
lepton ⇒ 0+0 → 0+0 (Conserved)
strangeness ⇒ 0+0 → −1−1 (Not Conserved)

State the conservation rule.
Go on to explain your answer.

[3 marks]

-Law of Conservation of Banyon Number
-Law of Conservation of Charge
-Law of Conservation of Lepton number
Since in strong nuclear interaction, strangeness is also conserved
-Law of Conservation of strangness

One way in which neutral pions decay is -Position

$$\pi^0 \rightarrow e^- + e^+ + \gamma$$

photon

0 2 . 3 Compare the rest energies of the particles involved in this decay.

[2 marks]

The interaction shows reaction of particle antiparticle pair (1.02 MeV required) + Gamma photon (extra energy). This shows π^0 has energy greater than 1.02 MeV

0 2 . 4 The decay of the neutral pion leads to the production of further gamma photons.

Explain why.

[1 mark]

$\pi^0 \rightarrow e^- + e^+ + \gamma$ ← recombine to create two more gamma due to annihilation

0 2 . 5 The Standard Model is a theory that classifies elementary particles. Evidence for the theory has been collected since about 1950. However, the term Standard Model has only been used since 1973.

Suggest why progress in particle physics is slow.

[1 mark]

-Need for international Collaboration and alot of funds.

3. June/2024/Paper_7408/1/No.4

0 4 The deuterium–tritium (D–T) reaction is a nuclear reaction between two isotopes of hydrogen.
The D–T reaction is

$\rho = 0$

$KE = 0$ $\quad KE \neq 0$

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + n$$

The energy from this reaction is transferred to the kinetic energy of the helium nucleus and the kinetic energy of the neutron.
Assume that the kinetic energies of the hydrogen nuclei are zero just before the reaction occurs.

0 4 . 1 Show that the kinetic energy of the neutron represents approximately 80% of the total energy transferred.

[2 marks]

$KE = \frac{1}{2} mv^2$

So. $KE = \frac{1}{2} \frac{m^2v^2}{m}$

$= \frac{1}{2} \frac{\rho^2}{m} = \frac{\rho^2}{2m}$

So

$KE = \frac{\text{Constant}}{2m}$ as ρ is conserved

So $KE \propto \frac{1}{m}$ So as mass of He-4 is 4 times of mass of neutrons Then out of 5, $\frac{1}{5}$ belongs to helium and the rest belongs to neutron. So 80% to neutrons

0 4 . 2 The combined kinetic energy of the helium nucleus and the neutron is 2.82×10^{-12} J.

Calculate the initial speed of the neutron.

[2 marks]

$KE = 2.82 \times 10^{-12}$ J

Since neutrons is 80% of total KE

KE of Neutron $= \frac{80}{100} \times 2.82 \times 10^{-12}$

$= 2.25 \times 10^{-12}$ J

So

$\frac{1}{2} mv^2 = 2.25 \times 10^{-12}$

$0.5 \times 1.675 \times 10^{-27} \times v^2 = 2.25 \times 10^{-12}$

$v = \sqrt{\frac{2.25 \times 10^{-12}}{0.5 \times 1.675 \times 10^{-27}}}$

$v = 5.19 \times 10^{7}$ m/s

initial speed = 5.19×10^{7} m s^{-1}

4. June/2024/Paper_7408/1/No.8

Which nuclear change results in the nucleus with the greatest specific charge?

[1 mark]

Specific charge = $\frac{\text{Charge}}{\text{Mass}}$

A the alpha decay of a $^{209}_{82}\text{Po}$ nucleus ☐

B the beta-minus decay of a $^{28}_{12}\text{Mg}$ nucleus ☐

C the beta-plus decay of a $^{39}_{20}\text{Ca}$ nucleus ☒

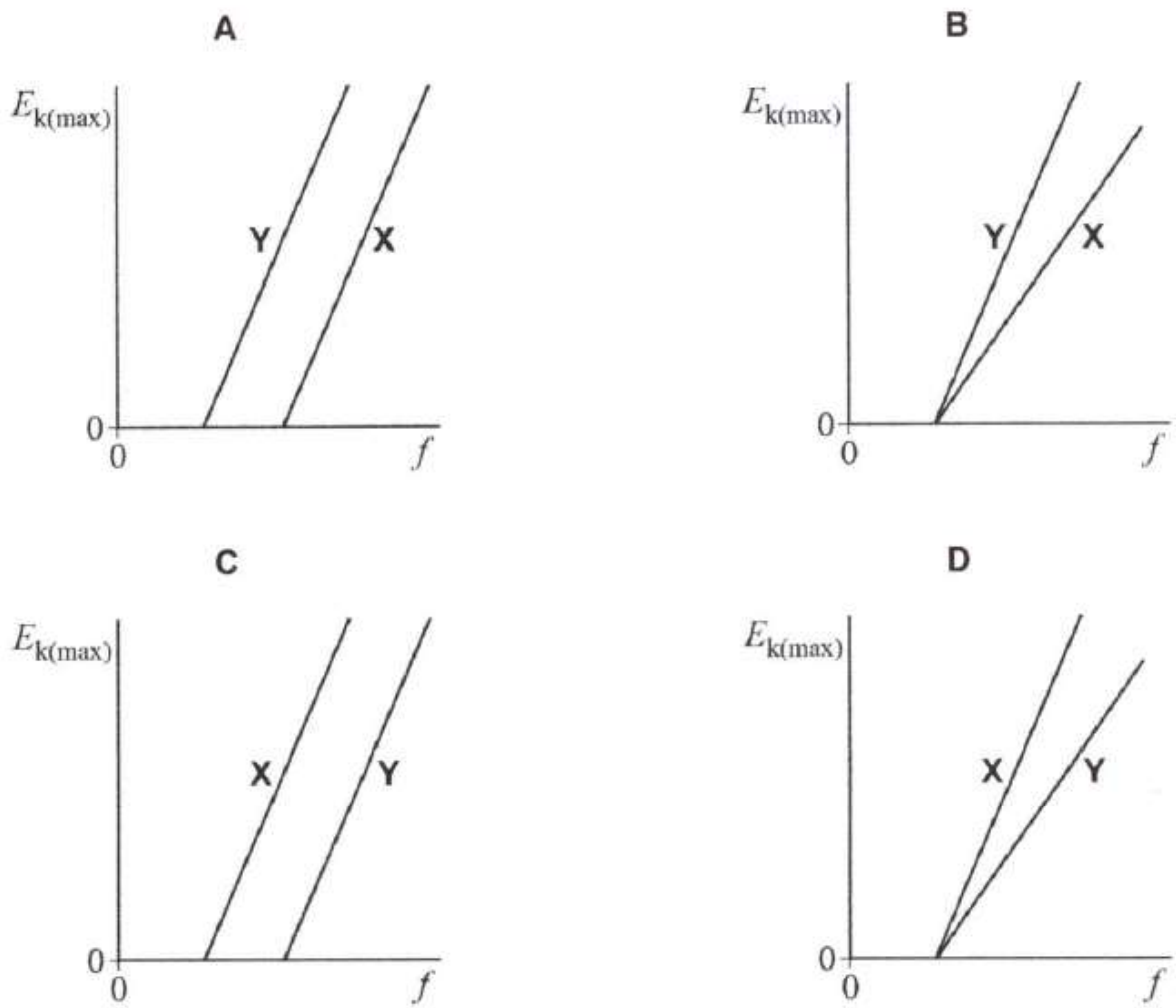
D electron capture by a $^{105}_{47}\text{Ag}$ nucleus ☐

5. June/2024/Paper_7408/1/No.9

In two separate experiments, electromagnetic radiation of variable frequency f is incident on the surfaces of plates made from metals **X** and **Y**.
The work function of **X** is greater than the work function of **Y**.

Which graph shows how the maximum kinetic energy $E_{k(max)}$ of photoelectrons emitted from the surfaces of the plates varies with f?

[1 mark]



A ☒

B ☐

C ☐

D ☐

$W_0 = hf_0$

If W_0 is greater then f_0 is greater so electrons are emmited from Y first befor X

6. June/2024/Paper_7408/1/No.10

Monochromatic light is incident on a metal surface in a vacuum and photoelectrons are emitted from the surface. The photoelectric current I is the rate of flow of charge from the surface.
The maximum kinetic energy of the photoelectrons is $E_{k(max)}$.
$E_{k(max)}$ and I are measured.

intensity is constant

The frequency of the light is then increased. There is no change to the rate at which energy is incident on the surface.

What happens to $E_{k(max)}$ and I when the frequency is increased?

[1 mark]

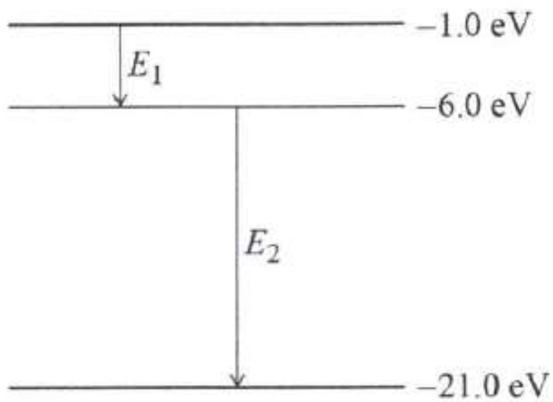
	$E_{k(max)}$	I	
A	increases	decreases	☒
B	increases	no change	☐
C	no change	no change	☐
D	no change	decreases	☐

The Max KE increase as $KE = hf - \phi$ and as f increases KE increases

If E_{total} is same, but E of photon increases, therefore fewer photons incident so fewer electrons liberated.

7. June/2024/Paper_7408/1/No.11

Three energy levels for an atom are shown.



$W = hf$ or $h\frac{c}{\lambda}$

$W_1 = h\frac{c}{\lambda_1}$

$-5eV = h\frac{c}{\lambda_1}$

$\lambda_1 = \frac{hc}{-5}$

$W_2 = h\frac{c}{\lambda_2}$

$\lambda_2 = \frac{hc}{-15}$

Energy change E_1 leads to the emission of a photon of wavelength λ_1.

Energy change E_2 leads to the emission of a photon of wavelength λ_2.

What is $\frac{\lambda_1}{\lambda_2}$?

$\frac{\lambda_1}{\lambda_2} = \frac{hc}{-5} \div \frac{hc}{-15}$

$= \frac{\cancel{hc}}{\cancel{-5}_{1}} \times \frac{\cancel{-15}^{3}}{\cancel{hc}}$

$= 3$

[1 mark]

A $\frac{1}{4}$ ☐

B $\frac{1}{3}$ ☐

C 3 ☒

D 4 ☐

8. June/2024/Paper_7408/1/No.12

An electron and a proton move with the same speed.

What is $\dfrac{\text{de Broglie wavelength of electron}}{\text{de Broglie wavelength of proton}}$?

$\lambda = \frac{h}{mv}$ and $\lambda \propto \frac{1}{m}$

so $\frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e} = \frac{1.67 \times 10^{-27}}{9.11 \times 10^{-31}} = 1833$

[1 mark]

A 5.5×10^{-4} ☐

B 2.3×10^{-2} ☐

C 42 ☐

D 1800 ☒