Practice Question Set For A-Level
**Subject : Physics**
**Paper-2 Topic: Fields And Their Consequences(Nuclear Physics)**

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**Name of the Student**:________________________________________________

**Max. Marks : 20 Marks** **Time : 20 Minutes**

Mark Schemes

## Q1.

(a) Any **two** from: ✔✔

- using electrons gives greater resolution (as the wavelength can be made very small)
- electrons can get closer to the nuclei (as there is no electrostatic repulsion)
- electrons have less recoil (as their mass is small compared to the nucleus)
- free electrons are easier to accelerate **OR** give energy to (as charge-to-mass ratio is higher)
- electrons are easier to produce
- scattering distributions are easier to interpret **OR** strong nuclear interaction is not involved
- using alpha particles only gives the distance of closest approach/upper limit to the radius.

*OWTTE on each advantage*

*Allow reverse arguments*

**2**

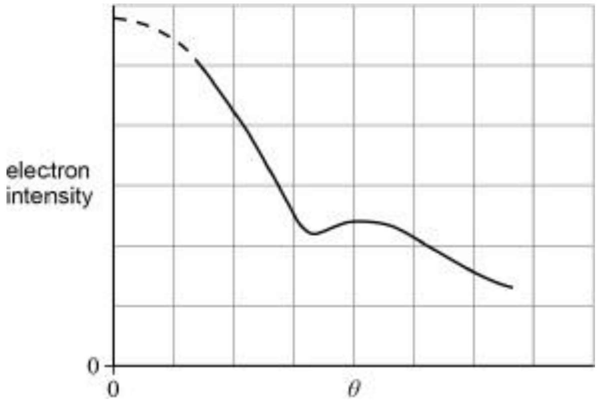
(b) A curved line showing an decrease in intensity with increase in θ.✔

There is a single **non-zero** minimum. ✔

*Do not allow U-shaped graphs.*

*The initial part of the curve may be absent.*

*Award MAX 1 for a line that covers less than half the θ axis.*




**2**

(c) Density (= mass÷volume) = $\frac{Am_{\text{nucleon}}}{\frac{4}{3}\pi R^3}$ ✔ 1 (substituting density = $\frac{Am_{\text{nucleon}}}{\frac{4}{3}\pi\left(R_0 A^{\frac{1}{3}}\right)^3}$ )

*✔$_1$ Do not accept M unlabelled.*
*Accept m (ie lowercase) unlabelled.*
*Condone $m_n$ (mass of neutron in Data sheet) for $m_{nucleon}$.*
*Accept only $1.67 \times 10^{-27}$ (kg) for mass of nucleon (ie to 3 sf).*

Density = $\frac{3m_{\text{nucleon}}}{4\pi(R_0)^3}$ (in which) all (terms are) constant **OR** the expression does not depend on $A$ ✔$_2$

*Allow ecf to MP2 for any misrepresentation of m provided it is clear that it signifies mass of a single nucleon.*

*✔$_2$ If the constants are identified the equation may be converted into a ratio. The equation may be rearranged to have $R_0$ as the subject with work to show that this is a constant when the density is constant.*

**2**

(d) Any **one** of: ✔

The mass of the nucleus is not exactly $A \times m_{\text{nucleon}}$

(because this ignores the binding energy)

**OR**

The volume equation assumes that the nucleus is a perfect sphere (which is not true) OWTTE

**OR**

The density equation that uses the nuclear radius formula implies that the density is uniform within a nucleus which is not true. OWTTE

**OR**

Protons have a slightly different mass to a neutron

*Do not accept "density of individual nucleons can be different from each other". It is not allowed as it does not occur in the working equation.*

**1**

(e) $R_0 = \left(\frac{R}{A^{\frac{1}{3}}} = \frac{4.02\times10^{-15}}{(35)^{\frac{1}{3}}}\right) = 1.2(3)\times10^{-15}$(m) ✔$_1$

Substitutes values into density equation ✔$_2$

*✔$_2$ e.g. Density=* $\left(\frac{\text{mass}}{\text{volume}} = \frac{Am}{\frac{4}{3}\pi R^3}\right) = \frac{35 \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi\left(4.02 \times 10^{-15}\right)^3}$

Density = $2.1 \times 10^{17}$ (kg m$^{-3}$) ✔$_3$

*✔$_3$ Evidence of a calculation must be given to gain this mark*
*Accept 2.15 but not 2.2*

**3**

## Q2.

(a) Heavy water

**OR**

Beryllium / Be

**OR**

(normal) Water ✔

*Accept $D_2O$ and $H_2O$*

1

(b) Any **two** points from: ✔✔

- U-235/Uranium fuel will (be more likely to) absorb the neutron
- slow neutrons are less damaging **OR** cause less fatigue to the structure of the reactor/shielding/etc
- slow neutrons (spend longer within the fissionable material and) increase the chance of causing fission
- slowing neutrons transfers heat energy to the moderator (which can make heat easier to extract)

all points OWTTE

*Condone the answer:*

*As an alternative to the first point Fission of U-236 is much more likely.*

*Condone the answer:*

*Absorption by U-238 is less likely.*

2

(c) $$\frac{\text{final kinetic energy}}{\text{initial kinetic energy}} = \left(\frac{\frac{1}{2}m_N v^2}{\frac{1}{2}m_N u^2}\right) = \left(\frac{v}{u}\right)^2$$ $= 0.85^2 = 72\%$ ✔$_1$

(Hence) proportion of kinetic energy lost = 28% ✔$_2$

*✔$_1$ can be for any of the terms shown equating to the kinetic energy ratio.*

*✔$_2$ can be an ecf but only for an arithmetic error.*

2

(d) final kinetic energy = ( $\frac{3}{2}$ $kT$ =) $7.2 \times 10^{-21}$ (J) ✔$_1$

initial kinetic energy = ($W = QV$) = $1.6 \times 10^{-13}$ (J) ✔$_2$

**OR**

final kinetic energy = 0.045 (eV) ✔$_1$

initial kinetic energy = $1.0 \times 10^{6}$ (eV) ✔$_2$

(Rearranging equation $y = \dfrac{\ln\left(\dfrac{E_0}{E_t}\right)}{}$)

✔$_{1+2}$ *Both marks must come from the same alternative route and have consistent units (which may not be seen).*

✔$_1$ *Initial kinetic energy =*

$\frac{3}{2} \times 1.38 \times 10^{-23} \times 350 = 7.245 \times 10^{-21}$ *J*

$= \dfrac{7.245\times10^{-21}}{1.60\times10^{-13}} = 0.045$ *eV*

✔$_2$ *Using the eV unit alternative the second mark cannot be given without an attempt at the first mark.*

*The 1.0 × 10*$^6$ *eV can be seen in a later substitution provided eV is used throughout.*

$y$ = 23.(2) ✔$_3$

✔$_3$ $y = \dfrac{\ln\left(\dfrac{1.0\times10^{6}}{0.045}\right)}{0.73} = 23.2$

*Condone answer 24 provided it is given as an integer.*

3

(e) Idea that the model/**Figure 3** shows that low nucleon number (and so low mass) gives a greater change/reduction in speed/KE (in a collision) ✔

Idea that fewer collisions needed (with a low mass number so moderator can be thinner) ✔

*Condone the use of nuclear mass instead of mass number.*

2

**[10]**