Answers prepared by Leong Yee Pak

NUCLEAR PHYSICS

27.1 the nucleus
27.2 isotopes

****June 02 P1 Q39 A** Nucleon number = 60 = number of protons + number of neutrons in nucleus. Proton number = 28 = number of proton in nucleus. Hence number of neutrons = 60 – 28 = . For a neutral atom, total charge = 0. Hence number of electron = number of proton

****Nov 02 P1 Q38 A** Isotopes are elements having the same number of proton in the nucleus.

***Nov 02 P1 Q39** A

***June 03 P1 Q38 C**

*****June 03 P1 Q40 D** Charge of a proton = +e = 2 x $\frac{2}{3}e + \left(-\frac{1}{3}e\right)$

***Nov 03 P1 Q39 B** Isotopes are elements having the same number of protons in the nucleus.

***June 04 P1 Q39 C**

***June 04 P1 Q40 D** Isotopes are elements having the same number of protons in the nucleus.

***Nov 04 P1 Q40 D**

****June 05 P1 Q38 C** Number of neutrons = number of nucleons – number of protons

***Nov 05 P1 Q39 B**

***June 06 P1 Q38 A**

***Nov 06 P1 Q39 D**

***Nov 07 P1 Q 36 C**

***Nov 07 P1 Q38 C**

****June 08 P1 Q39 C** The usual isotope of Uranium is Uranium-238. it has nucleon number 238. Hence mass of each nucleus = 238 u = 4 x 10^{-25} kg

***Nov 08 P1 Q38 D**

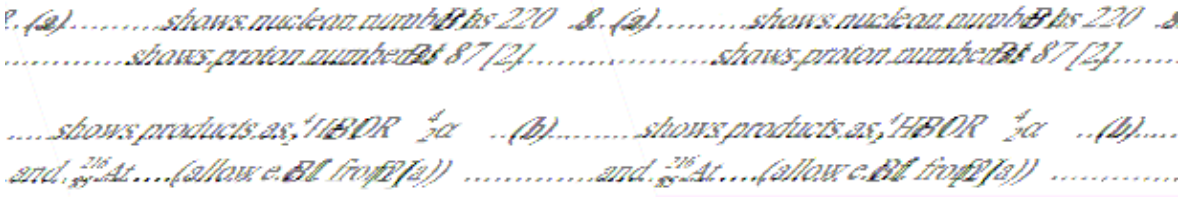
***Nov 08 P1 Q39 A** Isotopes have the same proton number Z but different nucleon number A.

****June 09 P1 Q36**

****June 09 P1 Q38**

Section B

Nov 02 P2 Q8



Nov 03 P2 Q6 (a) (i) 26 **(ii)** 30

(b)(i) mass ≈ 26 u = 4.32×10^{-26} kg

(ii) density = M/V = 4.32×10^{-26} / V. $V = \frac{4}{3}\pi r^3 =$

(c) Density of iron ball << density of nucleus. That is density of an atom << density of nucleus. Interference: the space within atom is very empty and almost all the mass of the atom is concentrated in a small space at the nucleus at the centre.

Nov 04 P2 Q7 (a)(i) The space within the atom is very empty.

(ii) All the protons and hence almost all the mass are concentrated at the centre of the atom

(b) CD deviated upwards but less than that of AB. Hence the path CD cuts the curve AB. EF deviates almost directly backwards but slight downwards.

Nov 07 P2 Q7 (a) The space within the atom is very empty. All protons are concentrated in a small space at the centre of the atom

(b)(i) atom: 10^{-10} m **(ii)** nucleus: 10^{-15} m to 10^{-14} m

27.3 Nuclear processes

***June 02 P1 Q38 C**

****June 02 P1 Q40 C** Number of neutron in mendelevium = 255 – 101 = 154. Number of neutron in bohrium = 154 + 2 +2 +2

****Nov 02 P1 Q40 C** Uranium-238 absorbs a neutron and become U-239. In β decay, a neutron in nucleus decays to produce a proton which remains in nucleus and an electron which is emitted as β-particles. Hence number of neutron decreased by 1 and the number of proton increases by 1. The nucleon number remains unchanged.

****June 03 P1 Q39 A** Refer to Nov 02 P1 Q40

***Nov 03 P1 Q38 C**

****Nov 03 P1 Q40 C** Nucleon number is conserved and total charge is conserved. ${}^{59}_{28}Ni + {}^{0}_{-1}e \rightarrow {}^{59}_{27}Co$

****June 04 P1 Q38 C** In β decay, a neutron in nucleus decays to produce a proton which remains in nucleus and an electron which is emitted as β-particles. Hence number of neutrons decreases by 1 and the number of protons increases by 1. The nucleon number remains unchanged.

For β-decay: A = 241, Z = 95. For α-decay: A = 241 – 4 = 237, Z = 95 – 2 = 93

****Nov 04 P1 Q38 D**

****Nov 04 P1 Q39 C** γ-radiation is e.m. radiation of very short wavelength / very high frequency. β-particles are high speed electrons. α-particles are helium nuclei, consisting of 2 protons and 2 neutrons.

****June 05 P1 Q39 C**

****June 05 P1 Q40 C** Nucleon number = 217 - 4 - 4 + 0 = 209; proton number = 85 – 2 – 2 +1 = 82

***Nov 05 P1 Q38 D** For β-decay, A remains the same, Z increases by 1

****Nov 05 P1 Q 40 D** Nucleon number is conserved and total charge is conserved. 16 + 4 = 19 + A. A = 1. 8 + 2 = 9 + Z. Z = 1

***June 06 P1 Q39 D** For β-decay, nucleon number A remains the same, proton number Z increases by 1

****June 06 P1 Q40 B** number of neutron = number of nucleon – number of proton

***Nov 06 P1 Q38 C**

****Nov 06 P1 Q40 B** let number of α-decay = x and the number of β-decay = y. New nucleon number = 222 – 4x = 214. X = 2. New proton number = 86 – 2x +y = 83. y = 1.

***June 07 P1 Q38 A**

***June 07 P1 Q39 D** For β-decay, nucleon number A remains the same, proton number Z increases by 1

*****June 07 P1 Q40 C** Loss in electric p.e. = gain in k.e. $qV = ½ mv^2$. $v^2 = \frac{2qV}{m}$. $v^2 = 2V\left(\frac{q}{m}\right)$.

The ratio of q/m for Li is the lowest.

***Nov 07 P1 Q37 C** In a β-decay, a neutron in the nucleus decays to form a proton which remains in the nucleus and an electron which is emitted as β-particle

****Nov 07 P1 Q39 B** For β-decay, nucleon number A remains the same, proton number Z increases by 1

*****Nov 07 P1 Q40 B** Loss in electric p.e. = gain in k.e. $qV = ½ mv^2$. $v^2 = \frac{2qV}{m}$. $v = \sqrt{\frac{2qV}{m}}$.

Momentum $p = mv = m\sqrt{\frac{2qV}{m}} = \sqrt{2mqV}$. For momentum greatest, the product mq greatest.

For Mo, mq = 100 x 42

****June 08 P1 Q40 B** For β-decay, nucleon number A remains the same, proton number Z increases by 1. For α-decay, nucleon number A is reduced by 4 and proton number Z reduced by 2.

****Nov 08 P1 Q40 A** α-decay: Nucleon number A decreases by 4 and Z decreases by 2. β-decay: A remains the same and Z increases by 1.

****June 09 P1 Q37 B**

***June 09 P1 Q39 C**

****June 09 P1 Q40 D**

Section B

June 02 P2 Q9(a) α-particle has low penetrating power. It cannot penetrate aluminium sheet.

(b) β-particles are absorbed by aluminium. The initial count rate is rate and falls with increasing thickness of aluminium sheet, indicating that β-particles were present and are absorbed by about 2 to 3 mm of aluminium.

(c) **γ-**radiation has high penetrating power. It can easily pass through aluminium sheet with very little absorption. Hence the count rate remains constant for various thickness of aluminium.

Nov 02 P2 Q8(a) $^{220}_{87}Fr$ Number of neutron = number of nucleon – number of proton = 220 - 87

(b) $^{220}_{87}Fr \rightarrow {}^{4}_{2}He + {}^{216}_{85}At$

June 03 P2 Q6 (a)(i) random: fluctuation in the count rate

(ii) the rate of decay is independent of temperature

(b)(i) Number of neutrons = number of nucleon – number of proton = 220 -86 = 134

(ii) $^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He$ Note: check that nucleon number is conserved and also proton number is conserved.

June 05 P2 Q8 (a) Nucleon number goes down by 4 to 227, and proton number reduced by 2 to 91. Position P = (91, 227).

(b) Position of Pu = (94, 243). For β-decay, A remains the same, Z increases by 1. Position of D = (95, 243)

June 06 P2 Q8 (a) The disintegration of an unstable nucleus with the emission of α-particle or β-particle and γ-radiation and energy.

(b) Spontaneous : The rate of decay is not affected by environment factors such as temperature or pressure.

(c) random: The probability of decay per unit time of each nucleus is the same. The time of decay of a particular nucleus cannot be predicted.

June 07 P2 Q7 (a) β-decay

(b) γ-decay. There is no change in nucleon number *A* and no change in proton number *Z*.

June 08 P2 Q7 (a)

α-particle	**β-particle**
helium nucleus	electron
Speed low	Speed high
discrete energy	a range of energy

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power	high ionization power	low ionization power
g power	low penetrating power	high penetrating power
u	mass ≈ 4u	mass ≈ 1/2000 u
	charge = +2e	charge = -e.

	high ionization power	low ionization
	low penetrating power	high penetratin
	mass ≈ 4u	mass ≈ 1/2000
	charge = +2e	charge = -e.

: nucleon number is conserved and the proton (Note: check that the nucleon number is conserved and the proton (Note: check that the number Z is conserved)

(ii) 1. Mark a dot at position (92, 237) and label it U.

2. Mark a dot at position (93, 237) and label it Np. (β-decay: A remains constant, Z increases by 1)

Nov 08 P2 Q8 (a) Random: The probability of decay per unit time of each nucleus is the same. The time of decay of a particular nucleus cannot be predicted.

(b)(i) Count rate is decreasing

(ii) fluctuation in the count rate

(c) The two curves are similar. The rate of decay is not affected by temperature change.

June 09 P2 Q8

8 **(a)** rate of decay / activity / decay (of nucleus) is not affected by external factors / environment / surroundings B2 [2]
(If states specific factor(s), rather than giving general statement above, then give 2 marks for two stated factors, but 1 mark only if one factor stated)

(b) (i) gamma / γ ..... B1 [1]

(ii) alpha / α ..... B1 [1]

(iii) gamma / γ ..... B1 [1]

(iv) beta / β ..... B1 [1]

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