Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2017/2018

COURSE NAME	:	ATOMIC AND NUCLEAR PHYSICS
COURSE CODE	:	BWC 20903
PROGRAMME	:	BWC
EXAMINATION DATE	:	DECEMBER 2017 / JANUARY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 (a) The configuration of electrons in an atom can be determined by a set of quantum number, namely: principle quantum number, angular momentum quantum number, magnetic quantum number and spin quantum number. Describe the physical meaning of each quantum numbers.

(8 marks)

(b) Show the electronic configuration for the following element:

(i) Vanadium (Z=23)
(ii) Chromium(Z=24)
(iii) Manganese(Z=25)

(8 marks)

(c) Explain the differences between K_α and K_β characteristic X-rays.

(4 marks)

Q2 (a) The nuclear binding energy for $^{235}_{92}U$ that corresponds to its mass defect is 1782.9042 MeV. Determine the rest mass of $^{235}_{92}U$ in unit u, given that 1u = 1.6605 $\times 10^{-27}$ kg = 931.494 MeV/c^2 , rest mass of a proton= 1.6726$\times 10^{-27}$ kg, rest mass of a neutron=1.6749 $\times 10^{-27}$ kg and rest mass of an electron= 9.109 $\times 10^{-31}$ kg,

(8 marks)

(b) The derivation of nuclear binding energy (in MeV) for liquid drop model using Weizsäcker semi -empirical mass formula is given by:

$$B = (i)15.56A \quad (ii)17.23A^{2/3} \quad (iii)0.697\frac{Z^2}{A^{1/3}} \quad (iv)23.285\frac{(N-Z)^2}{A} + \delta,$$

$$\delta = \begin{cases} +\dfrac{130}{A} & \text{(for even-even nuclei)} \\ 0 & \text{(for even-odd or odd-even nuclei)} \\ -\dfrac{130}{A} & \text{(for odd-odd nuclei)} \end{cases}$$

(i) Predict the suitable sign ("+" or "-") for (i), (ii), (iii) and (iv) of the equation.

(4 marks)

(ii) Using the equation, calculate B value for $^{235}_{92}U$ and compare the result with the nuclear binding energy stated in **Q2** (a).

(8 marks)

Q3 (a) The highest energy of α particle emitted in the decay of ^{238}U to Th is 4196 ± 4 keV. The mass of ^{238}U and $_2^4He^{2+}$ are 238.050 u and 4.00151 u respectively. Compute the mass of Th and give comments to your answer, given that 1u= 1.6605×10^{-27} kg = 931.494 MeV/c^2,

(4 marks)

(b) Thorium rock exists in nature in a single isotopic form ^{232}Th which decays very slowly. The radioactive decay of ^{232}Th rocks leads eventually to stable ^{208}Pb. A rock is determined to contain 3.65 g of ^{232}Th and 0.75 g of ^{208}Pb. The half life for ^{232}Th is 7340 years and half life for ^{208}Pb is 2 x10^{19} year.

(i) Determine the radioactivity ratio of ^{232}Th to ^{208}Pb in a 1g sample rock.

(ii) Given that the rate of decay of the natural ^{232}Th is 4/14 disintegration per minute per gram, estimate the age of the rock.

(10 marks)

(c) According to the nuclear shell model, the energy states in ascending order of nucleons inside a nucleus are $1s_{1/2}$, $1p_{3/2}$, $1p_{1/2}$, $1d_{5/2}$, $2s_{1/2}$, $1d_{3/2}$, $1f_{7/2}$, $2p_{3/2}$, $1f_{5/2}$,...,etc. Determine the spin, j and parity, η for the following ground state nuclei.

(i) $_{22}^{47}Ti$

(ii) $_3^6Li$

(6 marks)

Q4 (a) Among the radioactive products emitted from the 1986 Chernobyl reactor accident were ^{131}I ($t_{1/2}$ = 8.0 d) and ^{137}Cs ($t_{1/2}$ = 30 y). ^{137}Cs producing five times atoms more than ^{131}I atoms in fission.

(i) Assume the reactor had been operating continuously for several days before the radiation was released. Which isotope contributes the greater activity to the radiation cloud?

(ii) How long after the original incident does it take for the activities from both radionuclide to become equal?

(iii) Suggest the appropriate safety mechanism for Chernobyl reactor accident.

(12 marks)

(b) The government wants to build new nuclear power stations. If their plan succeeds, it will be at the cost of blocking the real solutions to climate change and a reliable future energy supply. Specify any assumptions that would need to be considered and give some examples to justify your assumptions. Be as realistic as possible in your approach to this problem.

(8 marks)

Q5 (a) Nuclear fusion is naturally found in stars. Fusion reaction powers the stars and the lightest elements produced in that process is known as a nucleosynthesis. Write sequence process involved in:

(i) Big Bang nucleosynthesis

(ii) Supernova nucleosynthesis

(10 marks)

(b) Every second, 600 million tons of hydrogen is being converted into helium. This reaction releases a tremendous amount of heat and energy. Thermonuclear fusion can be achieved by using an extremely high temperature.

(i) Conclude the basic of thermonuclear fusion process
(ii) Compare **TWO (2)** characteristics of fusion process with fission process

(10 marks)

- END OF QUESTIONS -