



UNIVERSITY EXAMINATIONS

SECOND SEMESTER 2023/2024 ACADEMIC YEAR

**FOURTH YEAR EXAMINATION FOR THE DEGREE OF
SCIENCE (GENERAL) AND BACHELOR OF
EDUCATION (SCIENCE)**

CHEM 423: RADIATION AND NUCLEAR CHEMISTRY

STREAM: R

TIME: 2 HRS

DAY: TUESDAY [11.30A.M – 1.30P.M] DATE: 09/04/2024

THIS QUESTION PAPER CONSISTS OF THREE (3) PAGES

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INSTRUCTIONS: Attempt All Questions**QUESTION ONE (30 MARKS)**

- a) What is meant by the term
- Mass defect (1 Mark)
 - Nuclear binding energy (1 Mark)
- b) The mass defect for the nuclide ${}^4_2\text{He}$ is found to be 0.0305 amu, calculate the binding energy of the nuclide in
- joules per mole of nuclei (2 Marks)
 - Joules per nucleus (1 Mark)
 - MeV per nucleus (1 Mark)
- c) i) State and explain the group displacement law in radioactivity. (2 Marks)
- ii) ${}^{210}_{82}\text{Pb}$ is a β -emitter and ${}^{226}_{88}\text{Ra}$ is an α -emitter. What will be the atomic masses and atomic numbers of daughter elements of these radioactive elements? Predict the position of daughter elements in the periodic table. (3 Marks)
- d) i) What is meant by carbon dating? (1 Mark)
- ii) The amount of carbon-14 in a piece of wood is found to be one-sixth of its amount in a fresh piece of wood. Calculate the age of old piece of wood.
The Half-life for carbon-14 is 5730 years. (3 Marks)
- e) i) Define the term nuclear reaction (1 Mark)
- ii) State the differences between a nuclear reaction and a chemical reaction (4 Marks)
- f) i) Name the types of radiations and compare their properties (6 Marks)
- ii) If Z be the atomic number and M the atomic mass of the parent nucleus, Using examples demonstrate the two main types of radioactive decay (4 Marks)

QUESTION TWO (20 MARKS)

- a) Distinguish between (4 Marks)
- Becquerel and Curie
 - Average life and half-life
- b) i) Calculate the half life and average life period of a radioactive element if its decay constant is $7.37 \times 10^{-3} \text{ hour}^{-1}$ (3 Marks)
- ii) A radioactive isotope has half-life period of 20 days. What is the amount of the isotope left over after 40 days if the initial concentration is 5 g? (3 Marks)
- iii) How much time would it take for a sample of cobalt-60 to disintegrate to the extent that only

2.0 per cent remains? The disintegration constant λ is 0.13 yr^{-1}

(3 Marks)

c) i) What is activity of a radioactive substance

(1 Mark)

ii) The half-life period of radon is 3.825 days. Calculate the activity of radon.

(atomic weight of radon = 222)

(3 Marks)

d) Explain the meaning of artificial radioactivity. Illustrate using an example

(3 Marks)

QUESTION THREE (20 MARKS)

a) i) Outline the steps for writing a nuclear equation

(2 Marks)

ii) Write the nuclear equation for the change that occurs in radium-226 when it emits an alpha particle.

(2 Marks)

iii) Cobalt-60 decays by emission of a beta particle. Predict the atomic number, mass

(2 Marks)

iv) Complete the nuclear equation

(2 Marks)



b) i) What is nuclear fission?

(1 Mark)

ii) State the characteristics of nuclear fission

(2 Marks)

c) By the aid of a well-labeled diagram, discuss the salient features of a nuclear power plant.

(5 Marks)

d) Discuss Fusion as a source of energy in the 21st century

(4 Marks)

The Periodic Table of the Elements

1 H Hydrogen 1.01																	2 He Helium 4.00														
3 Li Lithium 6.94	4 Be Beryllium 9.01																	10 Ne Neon 20.18													
11 Na Sodium 22.99	12 Mg Magnesium 24.31																	18 Ar Argon 39.95													
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80														
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29														
55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)														
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium 178.49	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)														
																		58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
																		90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium 168.93	102 No Nobelium (259)	103 Lr Lawrencium (262)

Legend for the diagram:

- 3 — Atomic Number
- Li — Element Symbol
- Lithium — Element Name
- 6.94 — Average Atomic Mass