KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: CHEM 422

COURSE TITLE: RADIATION AND NUCLEAR CHEMISTRY

STREAM: Y4S2

DAY: THURSDAY

TIME: 9.00 – 11.00 A.M.

DATE: 06/08/2009

INSTRUCTIONS TO CANDIDATES:

Attempt all questions

Each Question = 17.5 marks, Periodic Table provided,

Mass of particles: 1 proton = 1.0073 amu, 1 neutron = 1.0087 amu, 1 electron = 0.00054858 amu , 1 joule = 1 Kgm^2/s^2, 1 amu = 1.66056520 x 10^{-24} gms, Avogadro's No = 6.022 x 10^{23}

C = 3.0 x 10^8 m/s

PLEASE TURN OVER

1. (a) (i) Explain why the sum of the masses of all nucleons in a nucleus are not equal to the mass of the actual nucleus. (2 mks)

(ii) Describe what is meant by "magic number" of nucleons. Give examples (2 mks)

(iii) Compare and discuss the behaviors of α, β and γ radiation in an electric field, magnetic field and in various shielding materials. (4.5 mks)

(b) Calculate the following for $^{63}_{29}Cu$ (actual mass = 62.9298 amu): (6 mks)

(i) Mass deficiency in amu per atom

(ii) Mass deficiency in grams per mole

(iii) Binding energy in joules per mole

(c) Write the symbols for the daughter nuclei in the following radioactive decay: ($\beta = e^-$) (3 mks)

(i) $^{237}_{92}U \xrightarrow{-\beta}$ (ii) $^{13}C \xrightarrow{-n}$

(iii) $^{11}B \xrightarrow{-\gamma}$ (iv) $^{224}Ra \xrightarrow{-\alpha}$

(v) $^{18}F \xrightarrow{-p}$ (vi) $^{40}_{19}K \xrightarrow{+\beta}$

2. (a) (i) As the atomic number of an atom increases, the neutron / proton ratio increases. What does this suggest in nuclear stability? (2 mks)

(ii) Consider a radioactive nuclide with a neutron / proton ratio that is larger than those for the stable isotopes of that element. What mode(s) of decay might be expected for this nuclide and why? (2 mks)

(iii) Both barium-123 and barium- 140 are radioactive. Which is more likely to have longer half-life? Explain. (3 mks)

(b) Write nuclear equation for each of the following bombardment processes: (6 mks)

(i) $^{113}_{48}Cd\ (n, \gamma)\ ^{114}_{48}Cd$ (ii) $^{6}_{2}Li\ (n, \alpha)\ ^{3}_{1}H$

(iii) $^{2}_{1}H\ (\gamma, p)$ X. Identify X

(c) Write the nuclear equations for the following processes: (4.5 mks)

(i) Two deuterium ions undergoing fusion to give $^{3}_{2}He$ and a neutron.

(ii) A nuclide is bombarded by a neutron to form $^{7}_{3}Li$ and an α-particle (identify the unknown nuclide).

(iii) $^{14}_{7}N$ is bombarded by a neutron to form three α-particles and an atom of tritium.

3. (a) (i) What does the half-life of a radionuclide represent? (2.5 mks)

(ii) Explain how the stability of radionuclides is when compared in terms of half-life? (2 mks)

(b) (i) The half-life of Oxygen-19 is 29 seconds. What percentage of the isotope originally present would be left after 5.0 seconds? (4 mks)

(ii) The activity of a sample of tritium decreased by 5.5% over a period of a year. What is the half-life of tritium? (4mks)

(c) A sample of waste has a radioactivity, caused by strontium-90 (beta emitter, half-life = 28.1 years) of 0.245 Cig^{-1}. How many years will it take for its activity to decrease to 1.00×10^{-6} Cig^{-1}? (5 mks)

4. (a) (i) Describe the method of radiocarbon dating in determining the age of a material. (5.5 mks)

(ii) What factors limit the use of radiocarbon dating? (3 mks)

(b) What are the major advantages and disadvantages of fusion as a potential energy source compared with fission? (4 mks)

(c) A piece of wood taken from a cave dwelling in New Mexico is found to have a carbon-14 activity (per gram of carbon) only 0.636 times that of woodcut today. Calculate the age of the wood. (5 mks)