KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

THIRD YEAR second SEMESTER
Main EXAMINATIONS

FOR THE DEGREE OF BSC (chemistry) AND B.EE

COURSE CODE: SCH 322

COURSE TITLE: RADIATION AND NUCLEAR CHEMISTRY

DATE: 01/09/2022   TIME: 2:00PM-4:00PM

INSTRUCTIONS TO CANDIDATES:

TIME: 2 Hours

ANSWER QUESTION ONE AND ANY TWO OF THE REMAINING

THIS PAPER CONSISTS OF 5 PRINTED PAGES

KIBU OBSERVES ZERO TOLERANCE TO examination
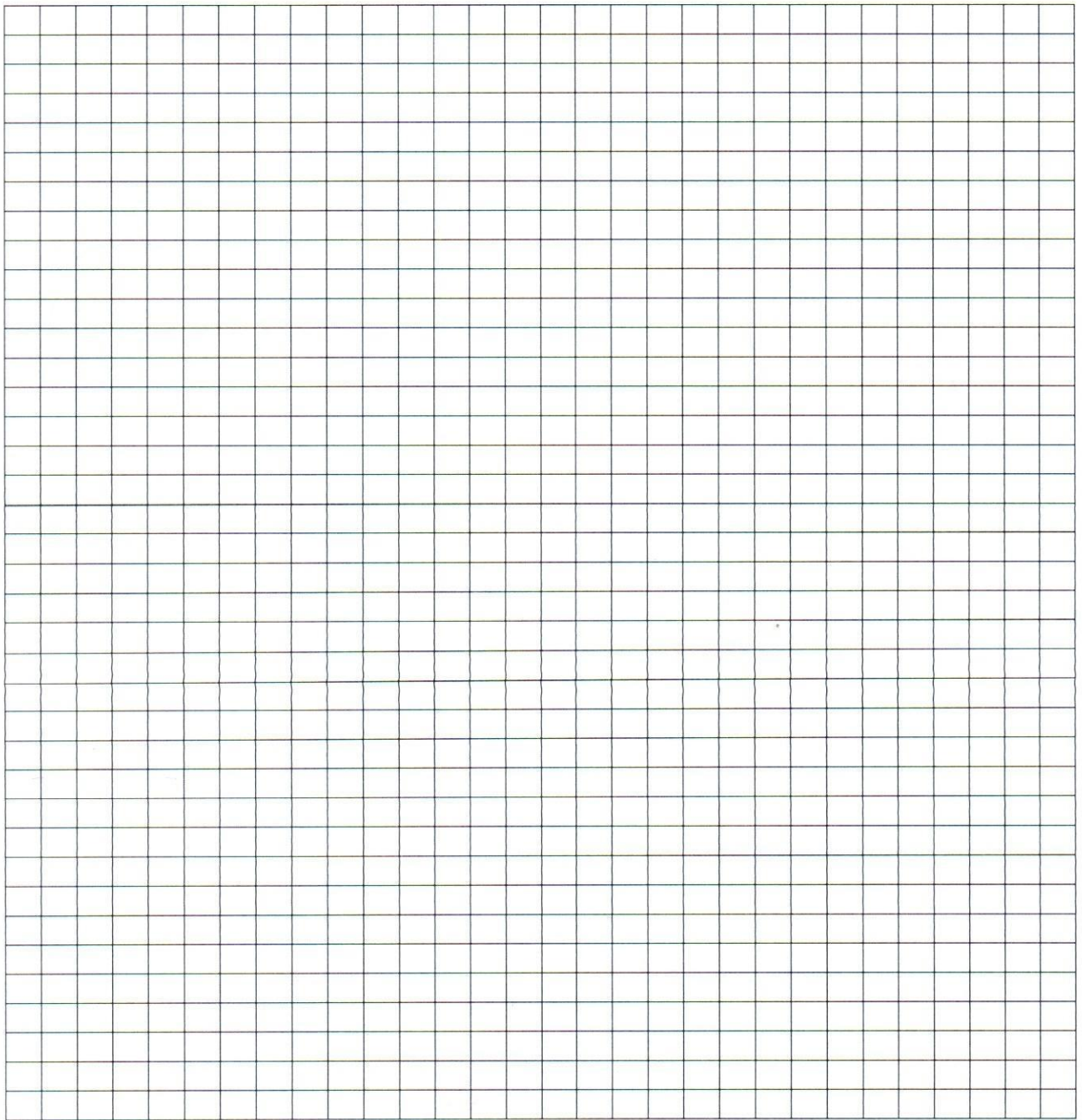
Question One (30 marks)

(a) Define the following terms   **(5 marks)**
  (i) Nuclear radiation
  (ii) Radioactivity
  (iii) Radioisotopes
  (iv) Isotones
  (v) Film budges

(b) Distinguish between nuclear reaction and chemical reaction   **(2 marks)**

(d) Alpha(α), beta (β) and gamma (γ) rays differ from each other in nature and properties. State the three chief properties   **(3marks)**

(e) State four methods used for detection and measurement of radioactivity   **(4 marks)**

(f) How many α and β particles are emitted in passing down from $^{230}_{90}Th$ to $^{206}_{82}Pb$ **(2marks)**

(g) State the Group Displacement Law'   **(2 marks)**

(h) Explain the meaning of radioactive disintegration series   **(1 mark)**

(i) State the three radioactive disintegration series   **(3 marks)**

(j) Calculate the half-life of radium-226 if 1 g of it emits 3.7×10^{10} alpha particles per second ($L = 6.023 \times 10^{23}$)   **(4marks)**

(k) Discuss some of the practical application of nuclear chemistry in   **(4 marks)**
  i.   Agriculture
  ii.   Carbon dating

Question Two (20 marks)

(a) Distinguish between isotopes and isotones by giving an example for each   **(4 marks)**

(b) What is meant by bremsstrahlung radiation   **(2 marks)**

(c) Briefly explain how bremsstrahlung radiation occurs   **(5 marks)**

(d) Balance the following nuclear equations and identify X   **(5 marks)**
  i. $^{210}Po_{84} \rightarrow {}^{206}Pb_{82} + X$
  ii. $^{137}Cs_{55} \rightarrow X + {}^{0}e_{-1}$
  iii. $^{26}Mg_{12} + 11p \rightarrow {}^{4}He_2 + X$
  iv. $^{235}U_{92} + 10n \rightarrow {}^{94}Kr_{36} + {}^{139}Ba_{56} + 3X$
  v. $^{14}N_7 + X \rightarrow {}^{17}O_8 + 11p$

(e) Differentiate between the following mean life and half-life   **(2 marks)**

(f) Determine the decay constant for carbon 14, if it has a half-life of 5730 years **(2 marks)**

Question Three (20 marks)

(a) Radioisotope $_{15}P^{32}$ has a half-life of 15 days. Calculate the time in which the radioactivity of its 1.0 mg quantity will fall to 10% of the initial value   **(5 marks)**

(b) Discuss the stability of nucleus in terms of neutron-proton ratio   **(4 marks)**

(c) Briefly explain what you understand by:
  (i) Nuclear fission   **(2marks)**.
  (ii) Nuclear fusion   **(2 marks)**

(d) Explain cosmic radiation as a natural source of radioactive radiations   **(5 marks)**

(e) State two artificial sources of radioactive radiation   **(2 marks)**

Question Four (20 marks)

(a) A sample of 2 g $^{209}Bi_{83}$ with a half-life 2.7×10^7 years decays into stable isotope of thallium by emitting alpha particle. What would be the activity of the sample after 2 years? (**3 marks**)

(b) An irradiated sample of gold gave the following results

Time/min	0	1	8	10	25	50	75	100
Counter/min	300	296	285	270	228	175	133	103

    (i) Draw the graph of counter per minute against time in minutes   (**5marks**)

    (ii) Determine the half-life of the isotope of gold   (**3 marks**)

    (iii) At what time will the activity of the sample be 210c/m   (**2marks**)

(c) Explain the two main mechanisms of how alpha particles interact with matter

    i) Excitation   (**2 marks**)

    ii) Ionization   (**2 marks**)

(d) Based on the even-odd rule, predict which one you would expect to be radioactive in each of the following pairs: (**3 Marks**)

    (i) O-16 or O-17

    (ii) Ne-20 or Ne-17

    (iii) Ca-40 or Ca-45

Question Five (20 marks)

(a)) Distinguish between subcritical and critical mass   (**2 marks**)

(b) Any nuclear reactor that produces power via the fission of uranium or plutonium by bombardment with neutrons must have at least five components. Name the five components   (**5 marks**)

(c) Explain why chain reaction does not occur in sub critical mass while it occurs in critical mass   (**4 marks**)

(d) State the five factor critical mass depends on   (**5 marks**)

(e) Explain how shield and containment systems operate in a nuclear reactor   (**4 marks**)

Periodic Table of the Elements

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 12.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.38	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.96	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [267]	dubnium 105 **Db** [268]	seaborgium 106 **Sg** [271]	bohrium 107 **Bh** [272]	hassium 108 **Hs** [270]	meitnerium 109 **Mt** [276]	darmstadtium 110 **Ds** [281]	roentgenium 111 **Rg** [280]	ununbium 112 **Uub** [285]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	ununhexium 116 **Uuh** [293]	ununseptium 117 **Uus** —	ununoctium 118 **Uuo** [294]

Key:
element name
atomic number
symbol
atomic weight (mean relative mass)

*lanthanoids	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.06
**actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]