THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATION

CH431 – INSTRUMENTAL ANALYSIS IV

FRIDAY 11TH JUNE 2021 8:20 AM

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES:

1. You will have 10 minutes to read the question paper. You **MUST NOT** begin writing in the answer book during this time.
2. **ANSWER ALL QUESTIONS.**
3. All answers **MUST** be written on the answer book provided
4. Calculators are permitted in the examination room. Lecture notes, notebooks plain papers and textbooks are **NOT** allowed.
5. Mobile phones are not allowed. **SWITCH OFF THE MOBILE PHONES.**
6. Show all workings and calculations in the answer book.
7. **DRAW the STRUCTURES** clear and visible.
8. **DO NOT** over write.
9. Write your name and number clearly on the front page. **DO IT NOW.**

MARKING SCHEME: Total 60 marks

1. (a) Name the TWO types of X-ray crystal monochromators.

[2 marks]

(b) Give mathematical expression for the following (*NO DERIVATION*):
(i) Relationship between the index of refraction and the velocity of light in the medium.
(ii) Unit cell edge length for a face centered cubic (FCC) structure.

[4 marks]

(c) Explain the measurement of X-ray intensities by Geiger-Muller tube counter.

[4 marks]

(Total = 10 marks)

2. (a) Name FOUR advantages of Flow-Injection Analysis (FIA) method.

(b) Calculate the frequency, wavenumber and energy (E) for typical ultraviolet radiation of wavelength 2000Å. Express the value of E in ergs.

(c) Draw a schematic diagram of an X-ray tube, label the major parts.

(d) Describe, how a Si(Li)-drifted detector operates?

(e) Distinguish between pneumatic and ultrasonic nebulizer.

(20 marks)

3. (a) What is Bragg's equation? Derive the Bragg's equation using reflection from two parallel planes as the model.

(b) Explain the energy band structures of Cu and Mg metal at 0K.

(c) Explain, how X-ray absorption technique is useful in the detection of broken bones in the human body?

(d) What do you mean by *Bremsstrahlung radiation* or explain in your own words what *Bremsstrahlung radiation* means?

(20 marks)

4. (a) Green light, $\lambda = 518$ nm, shines on a crystal of gallium arsenide (GaAs), which has a band gap energy, E_g, of 1.34 eV.
Does GaAs absorb this green light or not? Justify your answer with appropriate calculations.

(b) The mass absorption coefficient for Ni, measured with the CuK_α line is 49.2 cm^2/g. Calculate the thickness of a nickel foil that was found to transmit 58% of the incident power of a beam of CuK_α radiation. Assume that the density of Ni is 8.9 g/cm^3.

(10 marks)

DATA SHEET

Conversion table and physical constants

Planck constant,

h (in **J s**) = 6.63×10^{-34} J s

h (in **eV s**) = 4.13×10^{-15} eV s

h (in **erg-sec**) = 6.62×10^{-27} erg-sec

Speed of light (*in vacuo*), c = 3×10^8 m/s

1 J = 6.24×10^{18} eV

1 Å = 10^{-10} m

1 μm = 10^{-6} m

The Periodic Table

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 H 1.01																	2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Active Metals
Li > K > Ba > Sr > Ca > Na