UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	:	**YBB2023 - INORGANIC CHEMISTRY II**
DATE	:	**5 AUGUST 2024 (MONDAY)**
TIME	:	**9:00 AM - 12:00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **EIGHT (8)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. **FIGURE Q1** shows the plot of boiling points for some *p*-block hydrides.

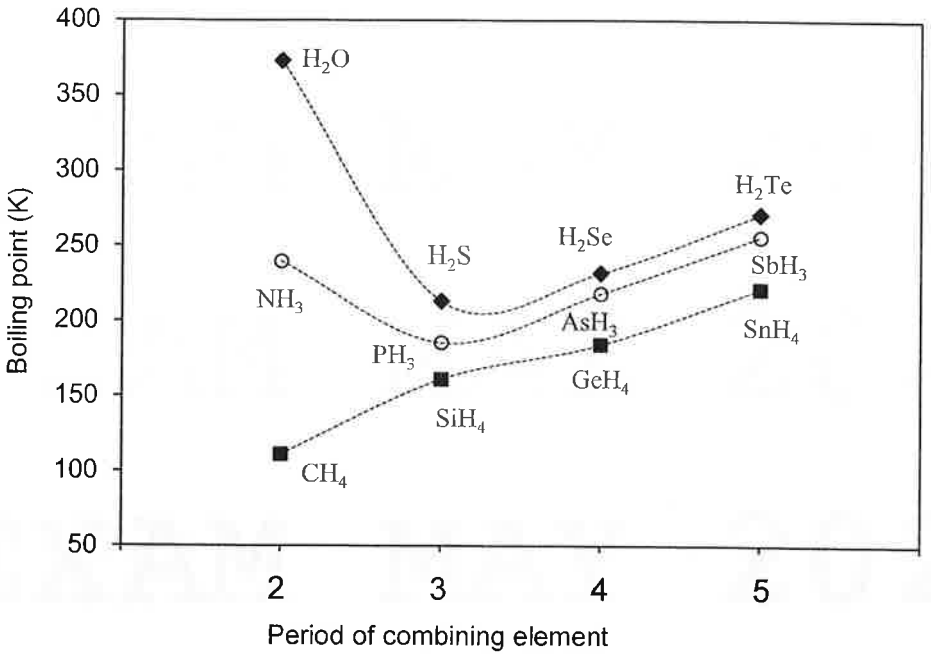

FIGURE Q1

i. Discuss and explain the trends and irregularities in the boiling point values for hydrides of each group as shown in **FIGURE Q1**.

[8 marks]

ii. Arrange Group 16 hydrides in the order of increasing acidity. Explain your answer.

[4 marks]

b. **M** is an *s*-block metal. **M** reacts vigorously with water to form **A** and a gas [Equation **1**]. **M** reacts with excess oxygen to form **B** (Equation **2**]. **B** dissolves in water to form **A** and hydrogen peroxide [Equation **3**]. The carbonate of **M** is soluble in water and stable on heating. **M** undergoes direct combination with hydrogen to form **C** [Equation **4**]. **C** reacts with water to form **A** and **D** [Equation **5**]. Determine the identity of **M** and write the balanced chemical equations to represent Equations **1** through **5** as described above.

[8 marks]

2. Explain each of the following observations. Provide examples, chemical structures or chemical equations, where necessary, to justify your answers.

a. The density of calcium is 1.54 $g.cm^{-3}$, while the density of strontium is 2.63 $g.cm^{-3}$.

[4 marks]

b. Both graphite and diamond are made from carbon, but they have different electrical conductivity properties.

[4 marks]

c. Aluminium oxide can react with both acids and bases.

[4 marks]

d. The enthalpy of atomization, $\Delta_a H°$ for alkali metals decreases on descending the group.

[4 marks]

e. Metal oxides and non-metal oxides show basic and acidic character, respectively, when dissolved in water.

[4 marks]

3. a. Acetic acid and gallane (GaH_3) exist as dimers in the vapour state. Differentiate the bonding that exists in each of the dimers. Provide structures to support your answer.

[6 marks]

b. Explain the role of the interhalogen compound in each of the following reaction. Justify your answer.

$$UF_4 + ClF_3 \rightarrow UF_6 + ClF$$

$$ClF_3 + SbF_5 \rightarrow [ClF_2]^+ [SbF_6]^-$$

[4 marks]

c. **TABLE Q3** shows the fourth ionization energy values, IE_4 for Group 15 elements.

TABLE Q3

Element	N	P	As	Sb	Bi
IE_4 ($kJ.mol^{-1}$)	7475	4964	4837	4260	4370

By using the data from **TABLE Q3**:

i. Explain the observed trend in IE_4 values.

[2 marks]

ii. Define the inert pair effect and relate it with the IE_4 values. Justify your answer.

[5 marks]

iii. Explain **ONE (1)** additional specific example of the inert pair effect on the properties of other elements in the periodic table.

[3 marks]

4. **TABLE Q4** contains the formulas of several complexes.

TABLE Q4

I	$Ca[IrBr_3Cl_3]$
II	$[Rh(NH_3)_2(CN)_2]^0$
III	$[Co(en)_3]^{3+}$
IV	$[Co(CO)_4(OH)_2][MnO_4]$ $[x]$ $[y]$

a. Determine the magnetic property of the complex **I**. Justify your answers.

[4 marks]

b. Hypothetical complex ion **II** converts its structure from tetrahedral to square planar upon heating. Determine the number of unpaired electron(s) in both structures. Justify your answer.

[5 marks]

c. Complex ion **III** was found to be diamagnetic and possesses enantiomers via optical isomerism. Justify its magnetic property and draw its possible structure(s).

[6 marks]

d. Compound **IV** consists of two complexes ions, x and y. Given that the oxidation number of manganese in the complex ion y is +7, propose the electron configuration of the *d*-block metal in the complex ion x using $(t_{2g})^n (e_g)^m$ form. Justify your answer.

[5 marks]

5. a. Two solutions are coloured green and orange. By using the Crystal Field theory, determine the solution which is likely to be low spin. Justify your answer.

[4 marks]

b. Consider the following hypothetical complexes:

$[Pa(en)_3Cl_3]^{2+}$ $[La(CN)_2(\boldsymbol{X})_3(NH_3)]^{n}$ $[PtCl_4F_5]^{3-}$

I **II** **III**

i. Name the complex ions **I** and **III** using the IUPAC system.

[4 marks]

ii. If the oxidation number of La in complex ion **II** is +3 and ligand $\boldsymbol{X}$ is oxalate ion, $C_2O_4^{2-}$, determine the value of n.

[2 marks]

iii. If complex ion **II** has similar coordination number as of complex ion **III**, sketch the structure of complex ion **II** to indicate the donor atom of each ligand. Note: Perspective drawing is not required.

[5 marks]

iv. Ligand $\boldsymbol{X}$ in complex ion **II** is replaced from oxalate ion to nitrite ion. Calculate the new value of n and draw the possible structure(s) of the new complex ion.

[5 marks]

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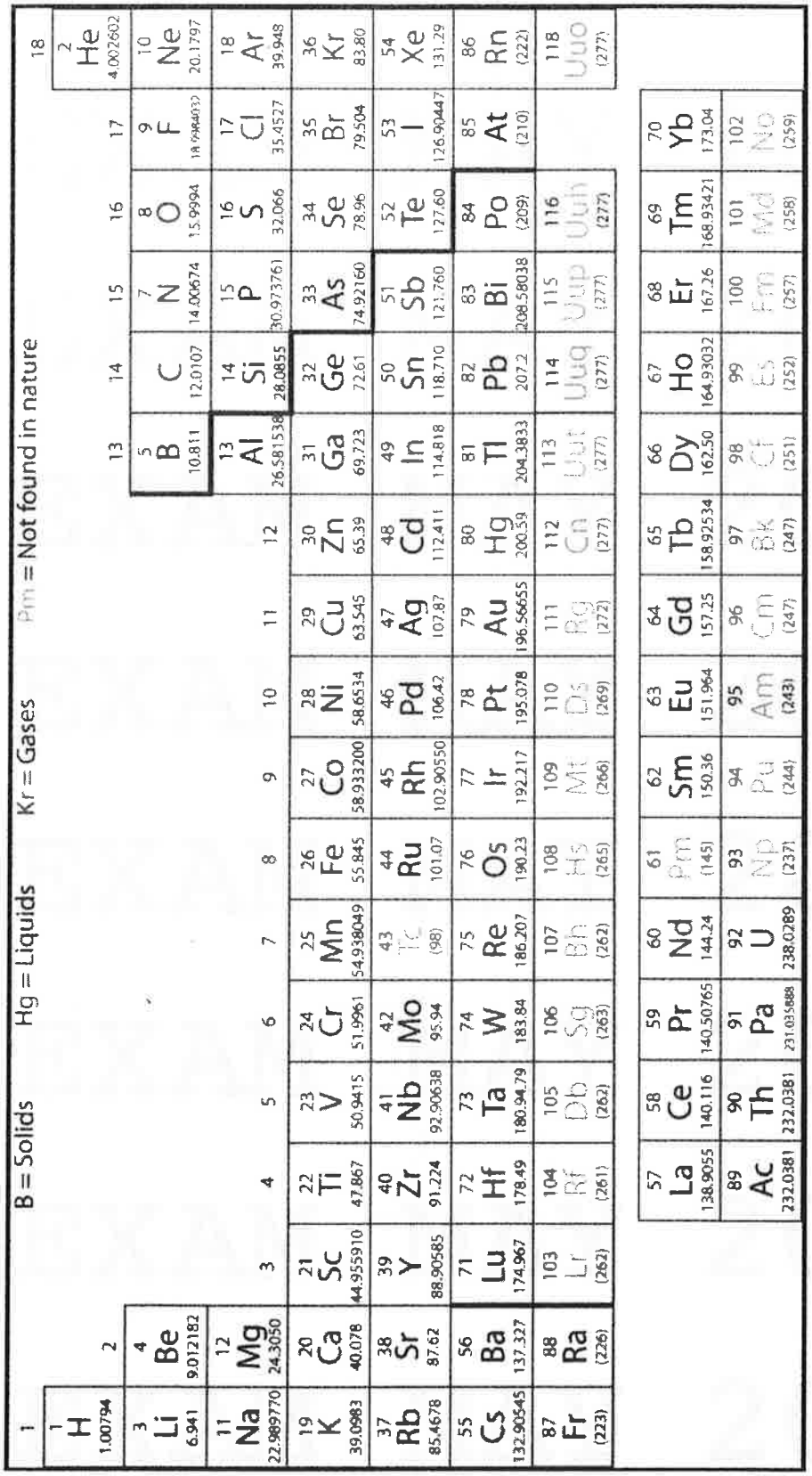
APPENDIX I (PERIODIC TABLE)



APPENDIX II (LIST OF ELEMENTS)

Name	Symbol	Atomic number	Atomic weight	Name	Symbol	Atomic number	Atomic weight
actinium	Ac	89	227.03[a]	mendelevium	Md	101	258.10[a]
aluminium	Al	13	26.98	mercury	Hg	80	200.59
americium	Am	95	243.06[a]	molybdenum	Mo	42	95.94
antimony	Sb	51	121.75	neodymium	Nd	60	144.24
argon	Ar	18	39.95	neon	Ne	10	20.18
arsenic	As	33	74.92	neptunium	Np	93	237.05[a]
astatine	At	85	209.99[a]	nickel	Ni	28	58.69
barium	Ba	56	137.33	niobium	Nb	41	92.91
berkelium	Bk	97	247.07[a]	nitrogen	N	7	14.01
beryllium	Be	4	9.01	nobelium	No	102	259.10[a]
bismuth	Bi	83	208.98	osmium	Os	76	190.23
bohrium	Bh	107	264.12[a]	oxygen	O	8	16.00
boron	B	5	10.81	palladium	Pd	46	106.40
bromine	Br	35	79.90	phosphorus	P	15	30.97
cadmium	Cd	48	112.41	platinum	Pt	78	195.08
calcium	Ca	20	40.08	plutonium	Pu	94	244.06[a]
californium	Cf	98	251.08[a]	polonium	Po	84	208.98[a]
carbon	C	6	12.01	potassium	K	19	39.10
cerium	Ce	58	140.12	praseodymium	Pr	59	140.91
caesium	Cs	55	132.91	promethium	Pm	61	145.00[a]
chlorine	Cl	17	35.45	protactinium	Pa	91	231.04
chromium	Cr	24	52.00	radium	Ra	88	226.03[a]
cobalt	Co	27	58.93	radon	Rn	86	222.02[a]
copper	Cu	29	63.55	rhenium	Re	75	186.21
curium	Cm	96	247.07[a]	rhodium	Rh	45	102.91
dubnium	Db	105	262.11[a]	rubidium	Rb	37	85.47
dysprosium	Dy	66	162.50	ruthenium	Ru	44	101.07
einsteinium	Es	99	252.08[a]	rutherfordium	Rf	104	261.11[a]
erbium	Er	68	167.26	samarium	Sm	62	150.35
europium	Eu	63	151.96	scandium	Sc	21	44.96
fermium	Fm	100	257.10[a]	seaborgium	Sg	106	266.00[a]
fluorine	F	9	19.00	selenium	Se	34	78.96
francium	Fr	87	223.02[a]	silicon	Si	14	28.09
gadolinium	Gd	64	157.25	silver	Ag	47	107.87
gallium	Ga	31	69.72	sodium	Na	11	23.00
germanium	Ge	32	72.61	strontium	Sr	38	87.62
gold	Au	79	196.97	sulfur	S	16	32.07
hafnium	Hf	72	178.49	tantalum	Ta	73	180.95
hassium	Hs	108	269.13[a]	technetium	Tc	43	98.00[a]
helium	He	2	4.00	tellurium	Te	52	127.60
holmium	Ho	67	164.93	terbium	Tb	65	158.93
hydrogen	H	1	1.01	thallium	Tl	81	204.37
indium	In	49	114.82	thorium	Th	90	232.04
iodine	I	53	126.90	thulium	Tm	69	168.93
iridium	Ir	77	192.22	tin	Sn	50	118.71
iron	Fe	26	55.85	titanium	Ti	22	47.90
krypton	Kr	36	83.80	tungsten	W	74	183.84
lanthanum	La	57	138.91	uranium	U	92	238.03
lawrencium	Lr	103	262.11[a]	vanadium	V	23	50.94
lead	Pb	82	207.19	xenon	Xe	54	131.30
lithium	Li	3	6.94	ytterbium	Yb	70	173.04
lutetium	Lu	71	174.97	yttrium	Y	39	88.91
magnesium	Mg	12	24.31	zinc	Zn	30	65.39
manganese	Mn	25	54.94	zirconium	Zr	40	91.22
meitnerium	Mt	109	268.14[a]				