

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.

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

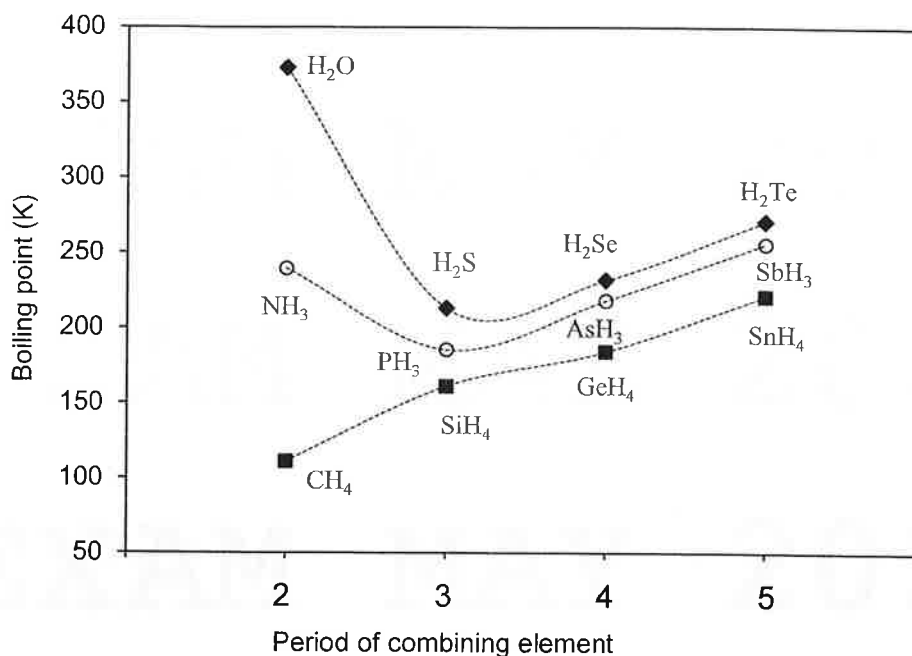


FIGURE Q1

- 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, $\Delta_a H^\circ$ for alkali metals decreases on descending the group.

[4 marks]

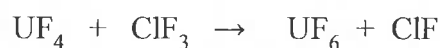
e. Metal oxides and non-metal oxides show basic and acidic character, respectively, when dissolved in water.

[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.



[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 ($\text{kJ}\cdot\text{mol}^{-1}$)	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

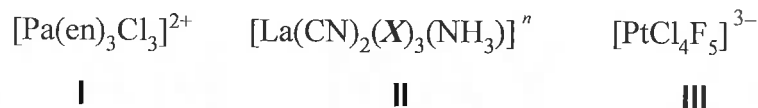
I	$\text{Ca}[\text{IrBr}_3\text{Cl}_3]$
II	$[\text{Rh}(\text{NH}_3)_2(\text{CN})_2]^0$
III	$[\text{Co}(\text{en})_3]^{3+}$
IV	$[\text{Co}(\text{CO})_4(\text{OH})_2][\text{MnO}_4]$ [x] [y]

- 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:



- 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 X is oxalate ion, $\text{C}_2\text{O}_4^{2-}$, 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 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]

-END OF PAPER-

APPENDIX I (PERIODIC TABLE)

B = Solids																		Hg = Liquids										Kr = Gases										Pm = Not found in nature																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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1 H 1.00794	2 He 4.002602	3 Li 6.941	4 Be 9.012182	5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797	11 Na 22.989770	12 Mg 24.3050	13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948	19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80	37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.87	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29	55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)	87 Fr (223)	88 Ra (226)	89 Ac (227)	90 Th 232.0381	91 Pa 231.036888	92 U 238.0289	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 (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Cn (277)	113 Nh (277)	114 Fl (277)	115 Uup (277)	116 Uuh (277)	117 Uuq (277)	118 Uuo (277)	119 Uuq (277)	120 Uub (277)	121 Uuc (277)	122 Uud (277)	123 Uue (277)	124 Uuf (277)	125 Uug (277)	126 Uuh (277)	127 Uui (277)	128 Uuj (277)	129 Uuk (277)	130 Uul (277)	131 Uum (277)	132 Uun (277)	133 Uuo (277)	134 Uuq (277)	135 Uur (277)	136 Uus (277)	137 Uut (277)	138 Uuv (277)	139 Uuq (277)	140 Uur (277)	141 Uus (277)	142 Uut (277)	143 Uuv (277)	144 Uuq (277)	145 Uur (277)	146 Uus (277)	147 Uut (277)	148 Uuv (277)	149 Uuq (277)	150 Uur (277)	151 Uus (277)	152 Uut (277)	153 Uuv (277)	154 Uuq (277)	155 Uur (277)	156 Uus (277)	157 Uut (277)	158 Uuv (277)	159 Uuq (277)	160 Uur (277)	161 Uus (277)	162 Uut (277)	163 Uuv (277)	164 Uuq (277)	165 Uur (277)	166 Uus (277)	167 Uut (277)	168 Uuv (277)	169 Uuq (277)	170 Uur (277)	171 Uus (277)	172 Uut (277)	173 Uuv (277)	174 Uuq (277)	175 Uur (277)	176 Uus (277)	177 Uut (277)	178 Uuv (277)	179 Uuq (277)	180 Uur (277)	181 Uus (277)	182 Uut (277)	183 Uuv (277)	184 Uuq (277)	185 Uur (277)	186 Uus (277)	187 Uut (277)	188 Uuv (277)	189 Uuq (277)	190 Uur (277)	191 Uus (277)	192 Uut (277)	193 Uuv (277)	194 Uuq (277)	195 Uur (277)	196 Uus (277)	197 Uut (277)	198 Uuv (277)	199 Uuq (277)	200 Uur (277)	201 Uus (277)	202 Uut (277)	203 Uuv (277)	204 Uuq (277)	205 Uur (277)	206 Uus (277)	207 Uut (277)	208 Uuv (277)	209 Uuq (277)	210 Uur (277)	211 Uus (277)	212 Uut (277)	213 Uuv (277)	214 Uuq (277)	215 Uur (277)	216 Uus (277)	217 Uut (277)	218 Uuv (277)	219 Uuq (277)	220 Uur (277)	221 Uus (277)	222 Uut (277)	223 Uuv (277)	224 Uuq (277)	225 Uur (277)	226 Uus (277)	227 Uut (277)	228 Uuv (277)	229 Uuq (277)	230 Uur (277)	231 Uus (277)	232 Uut (277)	233 Uuv (277)	234 Uuq (277)	235 Uur (277)	236 Uus (277)	237 Uut (277)	238 Uuv (277)	239 Uuq (277)	240 Uur (277)	241 Uus (277)	242 Uut (277)	243 Uuv (277)	244 Uuq (277)	245 Uur (277)	246 Uus (277)	247 Uut (277)	248 Uuv (277)	249 Uuq (277)	250 Uur (277)	251 Uus (277)	252 Uut (277)	253 Uuv (277)	254 Uuq (277)	255 Uur (277)	256 Uus (277)	257 Uut (277)	258 Uuv (277)	259 Uuq (277)	260 Uur (277)	261 Uus (277)	262 Uut (277)	263 Uuv (277)	264 Uuq (277)	265 Uur (277)	266 Uus (277)	267 Uut (277)	268 Uuv (277)	269 Uuq (277)	270 Uur (277)	271 Uus (277)	272 Uut (277)	273 Uuv (277)	274 Uuq (277)	275 Uur (277)	276 Uus (277)	277 Uut (277)	278 Uuv (277)	279 Uuq (277)	280 Uur (277)	281 Uus (277)	282 Uut (277)	283 Uuv (277)	284 Uuq (277)	285 Uur (277)	286 Uus (277)	287 Uut (277)	288 Uuv (277)	289 Uuq (277)	290 Uur 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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				