KOLEJ MATRIKULASI KEDAH

BAHAGIAN MATRIKULASI

KEMENTERIAN PENDIDIKAN MALAYSIA

PRA PSPM 1

SEMESTER II, SESI 2023/2024

KIMIA

2 jam

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIBERITAHU

ARAHAN KEPADA CALON:

Kertas ini mengandungi 6 soalan. Jawab semua soalan.

TABLE OF RELATIVE ATOMIC MASSES

Element	Symbol	Proton number	Relative atomic mass
Aluminium	Al	13	27.0
Silver	Ag	47	107.9
Argon	Ar	18	40.0
Arsenic	As	33	74.9
Gold	Au	79	197.0
Barium	Ba	56	137.3
Beryllium	Be	4	9.0
Bismuth	Bi	83	208.0
Boron	B	5	10.8
Bromine	Br	35	79.9
Iron	Fe	26	55.9
Fluorine	F	9	19.0
Phosphorus	P	15	31.0
Helium	He	2	4.0
Mercury	Hg	80	200.6
Hydrogen	H	1	1.0
Iodine	I	53	126.9
Cadmium	Cd	48	112.4
Potassium	K	19	39.1
Calcium	Ca	20	40.1
Carbon	C	6	12.0
Chlorine	Cl	17	35.5
Cobalt	Co	27	58.9
Cerium	Ce	58	140.1
Krypton	Kr	36	83.8
Chromium	Cr	24	52.0
Copper	Cu	29	63.6
Lithium	Li	3	6.9
Magnesium	Mg	12	24.3
Manganese	Mn	25	54.9
Sodium	Na	11	23.0
Neon	Ne	10	20.2
Nickel	Ni	28	58.7
Nitrogen	N	7	14.0
Oxygen	O	8	16.0
Platinum	Pt	78	195.1
Lead	Pb	82	207.2
Protactinium	Pa	91	231.0
Radium	Ra	88	226.0
Radon	Rn	86	222.0
Rubidium	Rb	37	85.5
Selenium	Se	34	79.0
Cerium	Ce	58	140.1
Cesium	Cs	55	132.9
Silicon	Si	14	28.1
Scandium	Sc	21	45.0
Tin	Sn	50	118.7
Antimony	Sb	51	121.8
Strontium	Sr	38	87.6
Sulphur	S	16	32.1
Uranium	U	92	238.0
Tungsten	W	74	183.9
Zinc	Zn	30	65.4

LIST OF SELECTED CONSTANT VALUES

Ionization constant for water at 25°C	K_w	$= 1.0 \times 10^{-14}$ mol^2 dm^{-6}
Molar volume of gases	V_m	$= 22.4$ dm^3 mol^{-1} at STP $= 24$ dm^3 mol^{-1} at room condition
Speed of light in a vacuum	c	$= 3.0 \times 10^8$ m s^{-1}
Specific heat of water		$= 4.18$ kJ kg^{-1} K^{-1} $= 4.18$ J g^{-1} K^{-1} $= 4.18$ J g^{-1} °C^{-1}
Avogadro's number	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
Faraday constant	F	$= 96500$ C mol^{-1}
Planck constant	h	$= 6.63 \times 10^{-34}$ J s
Rydberg constant	R_H	$= 1.097 \times 10^7$ m^{-1} $= 2.18 \times 10^{-18}$ J
Molar of gases constant	R	$= 8.314$ J mol^{-1} K^{-1} $= 0.08206$ L atm mol^{-1} K^{-1}
Density of water	ρ	$= 1$ g cm^{-3}
Freezing point of water		$= 0.00$ °C $= 273.15$ K
Vapour pressure of water at 25°C	P_{H_2O}	$= 23.76$ torr

UNIT AND CONVERSION FACTOR

VOLUME	1 L = 1 dm^3 1 mL = 1 cm^3
ENERGY	1 J = 1 kg m^2 s^{-2} = 1 N m = 1×10^7 erg 1 calorie = 4.184 J 1eV molecule^{-1} = 96.7 kJ mol^{-1}
PRESSURE	1 atm = 760 mmHg = 760 torr = 101 325 Pa = 101 325 N m^{-2}
TEMPERATURE	0°C = 273.15 K
OTHERS	1 Faraday (F) = 96 500 Coulomb 1 Newton (N) = 1 kg m s^{-2}

Answer **all** questions.

1 (a) Neon, Ne consists of 90.51% ^{20}Ne, 0.27% ^{21}Ne and 9.22% ^{22}Ne .The isotopic masses for these three isotopes are 19.99 amu, 20.99 amu and 21.99 amu, respectively. Calculate the relative atomic mass of Ne.

[3 *marks*]

(b) The following reaction takes place in acidic medium.

$Cr_2O_7^{2-} + SO_3^{2-} \longrightarrow Cr^{3+} + SO_4^{2-}$

Write the balanced equation for the above reaction.

[3 *marks*]

(c) A saline solution is prepared by dissolving 3.0 g of NaCl in water and is transferred to 250 mL volumetric flask. The density of the solution is 1.18g/mL. Calculate the molality of NaCl solution.

[5 *marks*]

(d) In experiment, 1.46g of magnesium is added into 160 mL of 0.50 M hydrochloric acid. The products formed are magnesium chloride solution and hydrogen gas.

(i) Write a balanced chemical equation for the above reaction.
(ii) Determine the limiting reactant.
(iii) Calculate the percentage yield if 672 mL of hydrogen gas is obtained at STP.

[10 *marks*]

NO.	PART	ANSWER SCHEME	MARKS
1	(a)	Average atomic mass of Ne $= \frac{\sum \mathbf{QiMi}}{\sum \mathbf{Qi}}$ @ $= \frac{90.51(19.99) + 0.27(20.99) + 9.22(21.99)}{(90.51 + 0.27 + 9.22)}$ = **20.18 amu**	1 1

		Relative atomic mass of Ne, A_r = $\frac{20.18 \text{ amu}}{\frac{1}{12} \text{x } 12 \text{ amu}}$ = **20.18**	1
	(b)	**(SO_3^{2-} + H_2O → SO_4^{2-} + $2H^+$ + 2e) x3** **$Cr_2O_7^{2-}$ + $14H^+$ + 6e → $2Cr^{3+}$ + $7H_2O$** **$3SO_3^{2-}$ + $Cr_2O_7^{2-}$ + $8H^+$ → $3SO_4^{2-}$ + $2Cr^{3+}$ + $4H_2O$**	1 1 1
	(c)	mole of NaCl = $\frac{3.0g}{58.5g\,mol^{-1}}$ = **0.0513 mol** $\rho = \frac{m_{soln}}{V_{soln}}$ $1.18 = \frac{mass\ of\ solution}{250}$ mass of solution = **295 g** mass of solvent = mass of solution – mass of solute = 295 – 3 = **292 g** Molality = $\frac{mol\ of\ solute}{mass\ of\ solvent(kg)}$@ = $\frac{0.0513\ mol}{0.292\ kg}$ = **0.176 m**	1 1 1 1 1
	(d)(i)	**Mg + 2HCl → $MgCl_2$ + H_2**	1
	(d)(ii)	Mole of HCl = 0.50 × 0.16 = **0.08 mol** (available) Mole Mg = $\frac{1.46g}{24.3g/mol}$ = **0.0601** mol (available) From equation, **2 mol HCl ≡1 mol Mg** 0.08 mol HCl ≡ 0.04 mol Mg (required) **Mole Mg available more than mole Mg required** Thus, Mg is excess reactant **HCl is the limiting reactant**	 1 1 1 1 1

	(d)(iii)	From equation, **2 mol HCl ≡ 1 mol H_2** 0.08 mol HCl ≡ 0.04 mol H_2 At STP, volume of H_2 = 0.04 mol x 22.4 L/mol = **0.896 L** % yield = $\frac{actual\ yield}{theoretical\ yield} \times 100\%$ @ = $\frac{0.672}{0.896} \times 100\%$ = **75%**	1 (compare with lim. reactant) 1 1 1
		TOTAL	**21**

2 (a) **FIGURE 1** shows the series of hydrogen emission spectrum in visible region.

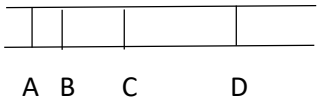


FIGURE 1

(i) Calculate the energy emitted to produce the third line in the series.
(ii) Explain the formation of line D.
(iii) Which line corresponds to the shortest wavelength?

[6 *marks*]

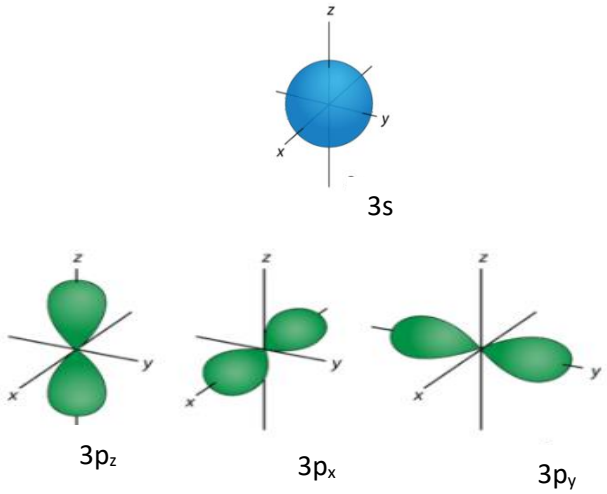
(b) Given below are the sets of quantum number for the highest energy electrons in atom X.

(3, 1, 0, +1/2) , (3, 1, -1, +1/2)

(i) Write the electronic configuration of atom X.
(ii) State the number of electrons in orbital of atom X with azimuthal quantum number, *l*=0.
(iii) Draw the shapes of orbitals occupied by the valence electrons.

[4 *marks*]

NO.	PART	ANSWER SCHEME	MARKS
2	(a)(i)	$\Delta E = R_H \left(\left(\frac{1}{n_{i^2}} - \frac{1}{n_{f^2}}\right)\right.$ @ $= 2.18 \times 10^{-18}\left(\frac{1}{5^2} - \frac{1}{2^2}\right)$ = **- 4.578 x 10^{-19} J**	1 1
	(a)(ii)	**An electron at the excited state** (**n=3**) is **unstable** and **fall back** to the **lower energy level** (**n=2**) Specific **energy in the form of photon/light is released**	1 1 1
	(a)(iii)	**Line A**	1
	(b)(i)	**$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$**	1
	(b)(ii)	**6**	1

	(b)(iii)		1 2 (any 2)
		TOTAL	11
		MAX	**10**

3 (a) An atom Y has 6 valence electrons. Y reacts with fluorine gas to form YF_2 and YF_6 compounds. For each compound,

(i) draw the Lewis structure.

(ii) predict the electron pair arrangement and the molecular geometry.

(iii) draw the molecular geometry and state the bond angle.

(iv) predict the type of hybridization of the Y atom.

[12 *marks*]

(b) **TABLE 1** shows the boiling points for several elements in the third period of periodic table.

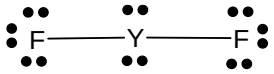
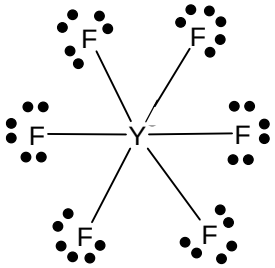
Element	Na	Mg	Al	Si	P	S
Boiling Point (^{0}C)	890	1120	2350	2680	281	445

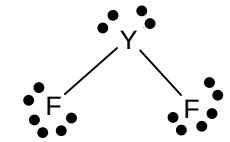
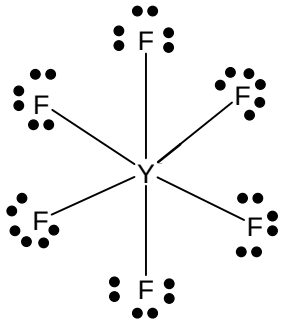
TABLE 1

(i) Based on the structure of the elements, explain why the boiling point rises form Na to Al.

(ii) Explain why Si has the highest boiling point.

[5 *marks*]

NO.	PART	ANSWER SCHEME	MARKS
3	(a) (i)	YF_2 	1
		YF_6 	1

	(a)(ii)	YF_2 Electron pair arrangement/basic shape : tetrahedral Molecular geometry : bent @ V-shaped YF_6 Electron pair arrangement/basic shape: octahedral Molecular geometry : octahedral	 1 1 1 1
	(a)(iii)	YF_2  bond angle : <<109.5^0 YF_6  bond angle : 90^0	 1 1 1 1
	(a)(iv)	YF_2 : sp^3 YF_6 : sp^3d^2	1 1
	(b)(i)	The boiling point rises form Na to Al because:- - **Na, Mg, Al** has **metallic bond** - The number of **valence electron increases from Na to Al** @ Al has highest number of valence electrons, followed by Mg and the least is Na - The **strength of metallic bond increase as the valence electron increase**	 1 1 1
	(b)(ii)	Each **Si is tetrahedrally bonded with another 4 Si atoms** with **strong covalent bond** between them Which **forms a giant covalent structure @ gigantic molecular structure**	1 1 1
		TOTAL	18
		MAX	**17**

4 (a) **FIGURE 2** shows two spheres with each volume of 5 L and 15 L are joint with a valve. Both spheres are filled with methane, CH_4 at pressure of 2 x 10^5 Nm^{-2} and nitrogen, N_2 at a pressure of 8 x 10^5 Nm^{-2} respectively. The valve is then opened and the gases are let to mix. Ignoring the volume taken by the valve, calculate the final pressure of the mixture at room temperature.

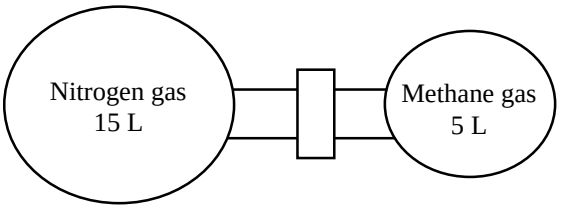


FIGURE 2

[5 *marks*]

(b) Give **ONE** difference between amorphous and crystalline solid.

[1 *mark*]

(c) **FIGURE 3** shows the phase diagram of H_2O.

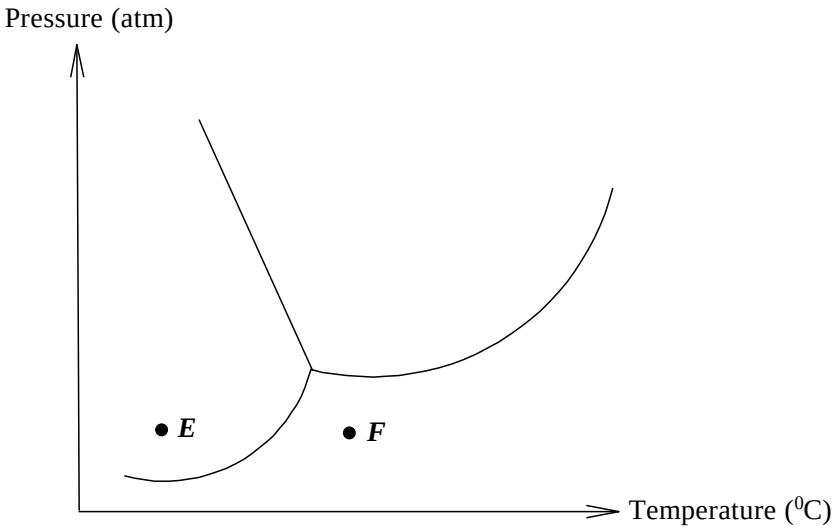


FIGURE 3

(i) Compare the solid-liquid equilibrium line of H_2O and CO_2.

(ii) Explain the anomalous behavior of H_2O.

(iii) State the condition of the kinetic energy of the water vapour when changing the phase from point ***F*** to ***E***.

[3 *marks*]

<table>
<tr><th>NO.</th><th>PART</th><th>ANSWER SCHEME</th><th>MARKS</th></tr>
<tr><td>4</td><td>(a)</td><td>After mixing, volume of mixture = 20 L

For CH_4
$P_1V_1 = P_2V_2$
P_{CH4} x (20) = (2 x10^5) x (5)
$P_{CH4} = 5 \times 10^4$ Nm^{-2}

For N_2
$P_1V_1 = P_2V_2$
P_{N2} x (20) = (8 x10^5) x (15)
$P_{N2} = 6 \times 10^5$ Nm^{-2}

Total pressure
$P_T = P_{CH4} + P_{N2}$ @
= (5 x 10^4) + (6 x 10^5)
= 6.5 x 10^5 Nm^{-2}</td><td>1

1

1

1
1</td></tr>
<tr><td></td><td>(b)</td><td><table><tr><td>Amorphous solid</td><td>Crystalline solid</td></tr><tr><td>Have random arrangement of particles / no well-defined or no ordered structure</td><td>Have regular repeated arrangement of particles / ordered structure</td></tr><tr><td>Formed when a saturated liquid is cooled rapidly</td><td>Formed when a saturated liquid is cooled slowly</td></tr></table></td><td>1
(any one pair correct statement)</td></tr>
<tr><td></td><td>(c)(i)</td><td>Phase diagram of water, H_2O has negative slope while phase diagram of CO_2 has positive slope</td><td>1
1</td></tr>
<tr><td></td><td>(c)(ii)</td><td>It is because ice is less dense (occupy larger volume) than water
@ it is because solid H_2O is less dense (occupy larger volume) than liquid H_2O</td><td>1</td></tr>
<tr><td></td><td>(c)(iii)</td><td>The kinetic energy of the water vapour decreases</td><td>1</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>10</td></tr>
<tr><td></td><td></td><td>MAX</td><td>9</td></tr>
</table>

5 (a) Consider a reaction below:

$2NOCl\ (g) \rightleftharpoons 2\ NO(g) + Cl_2\ (g)$

A 2.0 L flask contains 5.0 atm of NOCl was heated to 120°C. Analysis of the mixture at equilibrium shows that 1.25 atm Cl_2 was present.

(i) Calculate the partial pressure of NOCl and NO at equilibrium.
(ii) Calculate the equilibrium constant, K_p.

[5 *marks*]

(b) The decomposition of phosphorus pentachloride gas, PCl_5, is as follows:

$PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g) \qquad \Delta H = +92.5\ kJ$

Explain the effect on the amount of PCl_3 if
(i) the temperature is decreased.
(ii) argon gas is added at constant pressure.

[4 *marks*]

NO.	PART	ANSWER SCHEME	MARKS
5	(a)(i)	$2NOCl\ (g) \rightleftharpoons 2\ NO(g) + Cl_2\ (g)$ P_i/atm: 5.0 : 0 : 0 P_{change}/atm: -2x : +2x : +x P_{eq}/atm: 5-2x : 2x : x Given at equilibrium, x = 1.25 P_{NOCl} = 5-2x = 5-2(1.25) = **2.5 atm** P_{NO} = 2x = 2(1.25) = **2.5 atm**	1 (all correct) 1 1
	(a)(ii)	$K_p = \frac{(P_{NO})^2 (P_{Cl_2})}{(P_{NOCl})^2}$ @ $= \frac{(2.5)^2 (1.25)}{(2.5)^2}$ = **1.25**	1 1
	(b)(i)	The reaction is **endothermic**. When temperature decrease, the system will re-establish to increase the temperature. The equilibrium position will **shift to the left.** **Amount of PCl_3 will decrease.**	1 1 1

	(b)(ii)	When argon gas is added at constant pressure, the system will re-establish to increase the pressure of the reacting species. The equilibrium position will **shift to the right**. **Amount of PCl_3 will increase**.	1 1
		TOTAL	10
		MAX	**9**

6 (a) Write the equation for the ionization of 0.5 M aqueous solution of CH_3NH_2 and calculate its pH value. Given K_b for CH_3NH_2 is 3.7×10^{-4}.

[8 *marks*]

(b) The solubility of $PbSO_4$ in water is 0.038 gL^{-1}. Calculate the

(i) molar solubility of $PbSO_4$.

(ii) solubility product, Ksp of $PbSO_4$.

(iii) solubility of $PbSO_4$ in 0.01 M Pb^{2+} solution.

[6 *marks*]

NO.	PART	ANSWER SCHEME	MARKS
6	(a)	$CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$	1
		I (M): 0.5 | - | 0 | 0 C (M): $-x$ | - | $+x$ | $+x$ **E (M): 0.5-*x*** | **-** | ***x*** | ***x***	1
		$K_b = \frac{[OH^-][CH_3NH_3^+]}{[CH_3NH_2]}$ @ $3.7 \times 10^{-4} = \frac{[x][x]}{[0.5-x]}$	1
		Assume that *x* is very small, then **0.5-x ≈ 0.5**	1
		$3.7 \times 10^{-4} = \frac{x^2}{0.5}$ *x* = 0.0134 , *x* = -0.0138 (rejected)	
		$[OH^-]$ = ***x* = 0.0134** M	1
		pOH = -log $[OH^-]$@ = - log (0.0134)	1
		= **1.87**	1
		pH = 14 – pOH = 14 – 1.87 **= 12.13**	1
	(b)(i)	Molar solubility = $\frac{0.038\ gL^{-1}}{303.3\ gmol^{-1}}$ = **1.253×10^{-4} mol L^{-1}**	1

	(b)(ii)	$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$ $\boldsymbol{x}$ x $K_{sp} = [Pb^{2+}][SO_4^{2-}]$ @ $= (1.253 \times 10^{-4}) \times (1.253 \times 10^{-4})$ $\mathbf{= 1.57 \times 10^{-8}}$	1 1 1
	(b)(iii)	$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$ $0.01+y$ y $K_{sp} = [Pb^{2+}][SO_4^{2-}]$ $1.57 \times 10^{-8} = \mathbf{(0.01 + y)(y)}$ Ksp is very small, assume $0.01 + y \approx 0.01$ $1.57 \times 10^{-8} = 0.01\ y$ $y = \mathbf{1.57 \times 10^{-6}\ M}$	 1 1
		TOTAL	**14**