AL/2024/02/E-I

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கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2024
General Certificate of Education (Adv. Level) Examination, 2024

රසායන විද්‍යාව I இரசாயனவியல் I **Chemistry I**	**02 E I**

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

Instructions:

- *This paper consists of* **09** *pages.*
- *Periodic Table printed on page* **10** *can be detached if necessary.*
- *Answer* ***all*** *the questions.*
- ***Use of calculators is not allowed.***
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ \text{J s}$
Avogadro constant $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$ Velocity of light $c = 3 \times 10^{8}\ \text{m s}^{-1}$

1. Which of the following chemical species is expected to have the **highest** boiling point?
(1) He (2) Ne (3) CH_4 (4) N_2 (5) CO

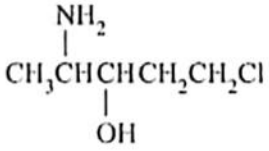
2. The orbital diagram in which both Aufbau principle and Hund's rule are violated is

	2*s*	2*p*
(1)	⇅	⇅ ↑ ○
(2)	↑	⇅ ↑ ○
(3)	⇅	↑ ↑ ↑
(4)	⇅	⇅ ↑ ↑
(5)	↑	⇅ ↑ ↑

3. In an atom, how many orbitals can have the quantum numbers $n = 3$, $m_l = -1$ and $n = 4$, $m_l = -1$?
(1) 2 (2) 3 (3) 4 (4) 5 (5) 6

4. The de Broglie wavelengths of two particles **X** and **Y** are 1 nm and 3 nm respectively. If the mass of **X** is three times the mass of **Y**, the ratio of kinetic energies of **X** and **Y** (**X**:**Y**) would be
(1) 1 : 4 (2) 1 : 3 (3) 3 : 4 (4) 3 : 1 (5) 4 : 1

5. What is the IUPAC name of the following compound?



(1) 2-amino-5-chloro-3-pentanol
(2) 4-amino-1-chloro-3-pentanol
(3) 5-chloro-3-hydroxy-2-pentanamine
(4) 1-chloro-3-hydroxy-4-pentanamine
(5) 2-amino-5-chloro-3-hydroxypentane

6. At temperature 25 °C, the pH of a saturated solution of metal hydroxide $M(OH)_2$ is
(K_{sp} of $M(OH)_2$ at 25 °C $= 4 \times 10^{-12}\ \text{mol}^3\ \text{dm}^{-9}$)
(1) 2 (2) 4 (3) 7 (4) 10 (5) 12

[*See page two*

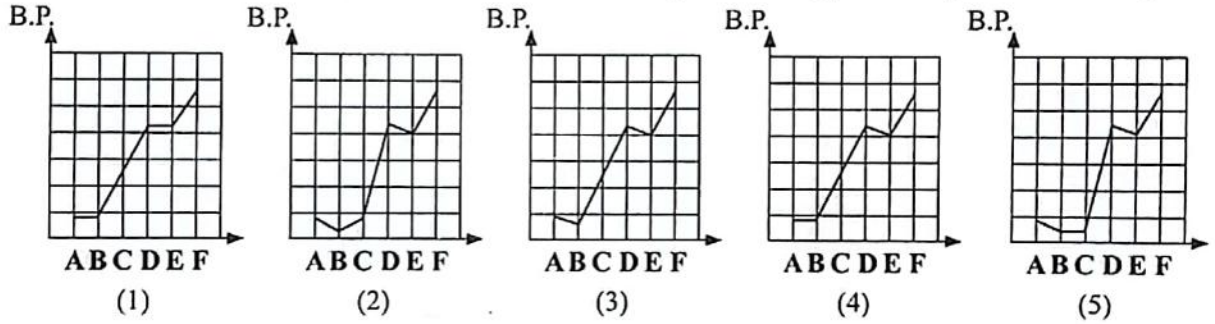
7. The shapes of IO_3^+, $NFCl_2$, F_3ClO_2 and F_4BrO^- are respectively
   (1) trigonal planar, trigonal pyramidal, square pyramidal and trigonal bipyramidal.
   (2) trigonal pyramidal, trigonal planar, square pyramidal and trigonal bipyramidal.
   (3) trigonal pyramidal, T-shape, trigonal bipyramidal and square pyramidal.
   (4) T-shape, trigonal planar, trigonal bipyramidal and square pyramidal.
   (5) trigonal planar, trigonal pyramidal, trigonal bipyramidal and square pyramidal.

8. Select the **incorrect** statement.
   (1) Among the chemical species NCl_3, SO_3 and PCl_5 the only polar species is NCl_3.
   (2) Among the elements Mg, Al, Si and P, the lowest first ionization energy is shown by Al.
   (3) Among the elements B, C and O, the lowest negative value for electron gain energy is shown by C.
   (4) Among the chemical species NO_3^-, SO_3, SO_3^{2-} and ClF_3, only NO_3^- and SO_3 have the same shape.
   (5) Among the ions Li^+, Na^+, Be^{2+} and Mg^{2+}, the largest difference in size is between Na^+ and Be^{2+}.

9. Consider the following compounds, **A**, **B**, **C**, **D**, **E** and **F**.

	$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CH(CH_3)CHO$
	A	**B**	**C**
Relative Molecular Mass	72	72	72
	$CH_3CH_2CH_2CH_2OH$	$CH_3CH(CH_3)CH_2OH$	$CH_3CH_2CH_2CH_2CH_2OH$
	D	**E**	**F**
Relative Molecular Mass	74	74	88

The variation of boiling points (B.P.) of these compounds is approximately shown best by



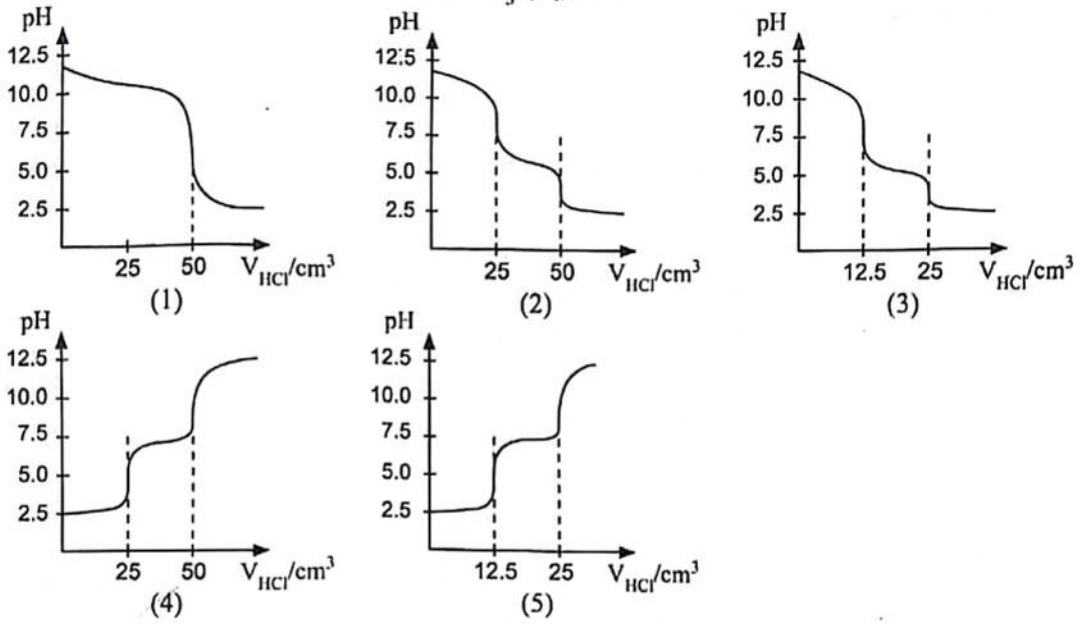
10. At a given temperature, a catalyst increases the rate of a reaction by
   (1) increasing the number of high energy collisions of reactant molecules.
   (2) increasing kinetic energy of reactant molecules.
   (3) increasing number of collisions among reactant molecules.
   (4) increasing the activation energy of the reaction.
   (5) providing a new pathway for the reaction.

11. $FeCl_3(s)$ reacts with $NH_3(g)$ and $H_2O(l)$ to produce $Fe(OH)_3$ and NH_4Cl.
   When 97.5 g of $FeCl_3(s)$, 34 g of $NH_3(g)$ and 27 g of $H_2O(l)$ are made to react, the maximum quantity of $Fe(OH)_3$ that can be obtained is
   (H = 1, N = 14, O = 16, Cl = 35.5, Fe = 56)
   (1) 21.3 g (2) 23.8 g (3) 53.5 g (4) 63.9 g (5) 71.3 g

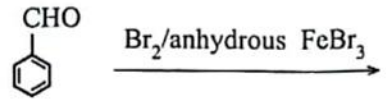
12. Bond energies of H—H, Cl—Cl and H—Cl are 436, 242 and 431 kJ mol^{-1} respectively. Enthalpy change (kJ mol^{-1}) of the reaction $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \longrightarrow HCl(g)$ is
   (1) −184 (2) −92 (3) 92 (4) 184 (5) 247

[See page three

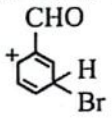
13. Which of the following figures correctly represents the titration curve when 0.100 mol dm^{-3} HCl(aq) is added to 25.00 cm^3 of 0.05 mol dm^{-3} CO_3^{2-}(aq) solution?

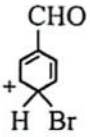


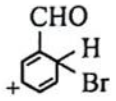
14. Consider the following reaction.

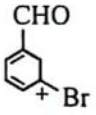


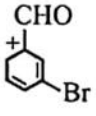
Which of the following is a resonance structure of the intermediate which gives the major product of the above reaction?

(1) 

(2) 

(3) 

(4) 

(5) 

15. Consider the reaction of $KMnO_4$(aq) with H_2O_2(l) in the presence of dilute H_2SO_4(aq). The correct co-efficients of the reactants when the chemical equation of the reaction is balanced with the smallest whole number co-efficients are

	MnO_4^-(aq)	H_2O_2(l)	H^+(aq)
(1)	2	3	10
(2)	2	4	6
(3)	2	5	6
(4)	2	5	8
(5)	2	5	16

16. A first-order gas phase reaction $A(g) \longrightarrow B(g) + C(g)$ occurs in a closed container at a given temperature. The half-life $\left(t_{1/2}\right)$ of the reaction is 20 s when the initial pressure is 100 kPa. The half-life of the reaction when the initial pressure is 200 kPa at the same temperature is

(1) 10 s (2) 20 s (3) 40 s (4) 400 s (5) 800 s

17. Consider the reactions shown below.

$$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g) \quad ; \quad \Delta H = -241.8 \text{ kJ mol}^{-1}$$

$$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l) \quad ; \quad \Delta H = -285.8 \text{ kJ mol}^{-1}$$

Enthalpy change of vaporization (kJ mol^{-1}) of water is

(1) −88 (2) −44 (3) 0 (4) 44 (5) 88

[See page four

18. When solutions of reactants **A** and **B** are mixed in a beaker, a spontaneous reaction takes place with the lowering of the temperature of the mixture. Which of the following is correct for the reaction between **A** and **B**?

	ΔH	ΔS
(1)	–	+
(2)	–	–
(3)	–	0
(4)	+	–
(5)	+	+

19. Select the correct statement with regard to the given reaction.

$CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$

(1) $CH_3NH_2(aq)$ behaves as a Lewis-acid in the forward reaction while $CH_3NH_3^+(aq)$ behaves as a Lewis-base in the reverse reaction.

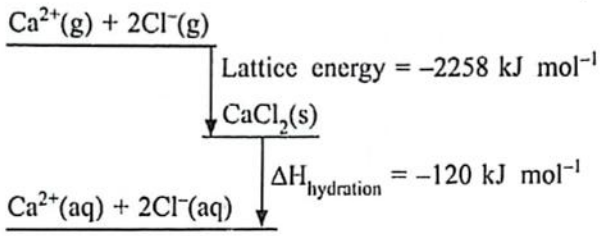
(2) $H_2O(l)$ behaves as a Lewis-base in the forward reaction while $OH^-(aq)$ behaves as a Lewis-base in the reverse reaction.

(3) $CH_3NH_2(aq)$ behaves as a Lewis-base in the forward reaction while $OH^-(aq)$ behaves as a Lewis-acid in the reverse reaction.

(4) $H_2O(l)$ behaves as a Lewis-acid in the forward reaction while $CH_3NH_3^+(aq)$ behaves as a Lewis-base in the reverse reaction.

(5) $CH_3NH_2(aq)$ behaves as a Lewis-base in the forward reaction while $OH^-(aq)$ behaves as a Lewis-base in the reverse reaction.

20. Consider the enthalpy diagram shown below.



The enthalpy change of hydration of $Ca^{2+}(g)$ is –1650 kJ mol^{-1}. The hydration enthalpy change of $Cl^-(g)$ (kJ mol^{-1}) is

(1) –728 (2) –364 (3) 364 (4) 728 (5) 2378

21. Consider the following reaction scheme.

$$CH_3C{\equiv}CH \xrightarrow[\text{Quinoline}]{H_2/\text{Pd-BaSO}_4} \mathbf{A} \xrightarrow[\text{(Peroxides)}]{\text{HBr}} \mathbf{B}$$

A and **B** respectively could be:

(1) $CH_3CH_2CH_3$ and $CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_3$

(2) $CH_3CH{=}CH_2$ and $CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_3$

(3) $CH_3CH_2CH_3$ and $CH_3CH_2CH_2Br$

(4) $CH_3CH{=}CH_2$ and $CH_3CH_2CH_2Br$

(5) $CH_3CH{=}CH_2$ and $CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_2Br$

[See page five

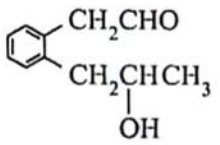
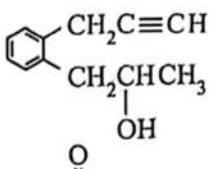
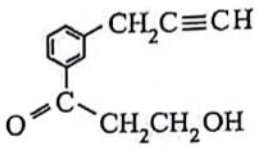
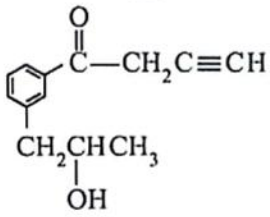
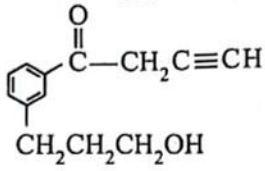
22. At a given temperature, the reaction $3ClO^-(aq) \longrightarrow ClO_3^-(aq) + 2Cl^-(aq)$ occurs through the following mechanism.

$$ClO^-(aq) + ClO^-(aq) \longrightarrow ClO_2^-(aq) + Cl^-(aq) \text{ (slow)}$$
$$ClO_2^-(aq) + ClO^-(aq) \longrightarrow ClO_3^-(aq) + Cl^-(aq) \text{ (fast)}$$

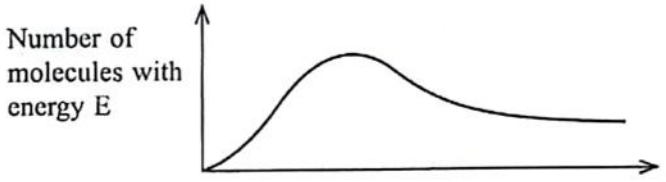
The rate law of this reaction is, (k = rate constant)

(1) rate = $k[ClO^-(aq)]$
(2) rate = $k[ClO^-(aq)]^3$
(3) rate = $k[ClO^-(aq)]^2$
(4) rate = $k[ClO_2^-(aq)]\,[ClO^-(aq)]$
(5) rate = $k[Cl^-(aq)]\,[ClO^-(aq)]$

23. Compound **A** forms a coloured precipitate with 2,4-dinitrophenylhydrazine (2,4-DNP). Compound **A** also forms a precipitate with ammoniacal $AgNO_3$.
Compound **A** reacts with acidified $K_2Cr_2O_7$ to give product **B** and a green colour solution.
Compound **B** does not dissolve in aqueous Na_2CO_3.
Compound **A** could be:

(1) 
(2) 
(3) 
(4) 
(5) 

24. At a given temperature the distribution of kinetic energies of molecules of a gas within a sealed container is shown in the following graph.



Some of the gas is removed and the container resealed; then the gas is cooled. Which of the following correctly describes the change in the graph?

	Area under the curve	**Position of the maximum point**
(1)	decrease	shift to the left
(2)	increase	shift to the left
(3)	no change	shift to the left
(4)	decrease	shift to the right
(5)	no change	no change

25. Consider the electrochemical cell operating at temperature 298 K given below.

$$Zn(s) \mid Zn^{2+}(aq,\ 1.0 \text{ mol dm}^{-3}) \parallel Fe^{2+}(aq,\ 1.0 \text{ mol dm}^{-3}),\ Fe^{3+}(aq,\ 1.0 \text{ mol dm}^{-3}) \mid Pt(s)$$

Which of the following gives the correct overall cell reaction and E^o_{cell}?

$E^o_{Zn^{2+}(aq)/Zn(s)} = -0.76$ V $\quad E^o_{Fe^{3+}(aq)/Fe^{2+}(aq)} = +0.77$ V

	Cell reaction	E^o_{cell} /(V)
(1)	$Zn(s) + 2Fe^{3+}(aq) \longrightarrow 2Fe^{2+}(aq) + Zn^{2+}(aq)$	1.53
(2)	$Zn(s) + 2Fe^{3+}(aq) \longrightarrow 2Fe^{2+}(aq) + Zn^{2+}(aq)$	−1.53
(3)	$Zn(s) + 2Fe^{3+}(aq) \longrightarrow 2Fe^{2+}(aq) + Zn^{2+}(aq)$	0.01
(4)	$Zn^{2+}(aq) + 2Fe^{2+}(aq) \longrightarrow 2Fe^{3+}(aq) + Zn(s)$	−1.53
(5)	$Zn^{2+}(aq) + 2Fe^{2+}(aq) \longrightarrow 2Fe^{3+}(aq) + Zn(s)$	−0.01

[*See page six*

26. Consider the reaction below taking place in a closed-rigid container at a given temperature.

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$; $\Delta H = -900$ kJ mol^{-1}

Which of the following statements is true for this reaction?

(1) High pressure and high temperature give the highest equilibrium amount of NO(g).
(2) Low pressure and high temperature give the highest equilibrium amount of NO(g).
(3) High pressure and low temperature give the highest equilibrium amount of NO(g).
(4) Low pressure and low temperature give the highest equilibrium amount of NO(g).
(5) Changes in pressure and temperature have no effect on the equilibrium amount of NO(g).

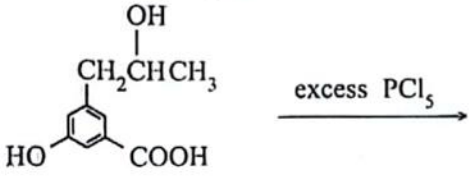
27. The following information is displayed on the label of a bottle which contains concentrated NH_3 solution.

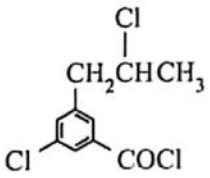
NH_3 content – 30.0% (by mass)
density – 0.850 g cm^{-3}

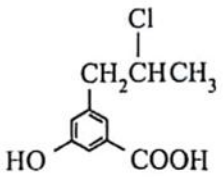
When 400.0 cm^3 of this NH_3 solution was reacted completely with H_2SO_4, the amount of ammonium sulfate that can be formed is
(H = 1, N = 14, O = 16, S = 32)

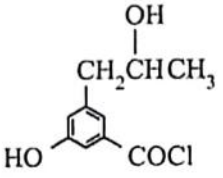
(1) 132 g (2) 396 g (3) 528 g (4) 792 g (5) 1584 g

28. What is the major product of the following reaction?



(1)


(2)


(3)


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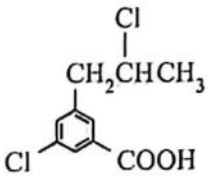

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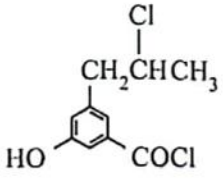


29. A wood ash sample **X** contains $CaCO_3$, K_2CO_3, and an inert material. In **X** the molar ratio of $CaCO_3$:K_2CO_3 is 2:1. A 1.0 g sample of dry powdered **X** was reacted with excess HCl. The concentration and volume of HCl used was 0.30 mol dm^{-3} and 25.0 cm^3 respectively. After the reaction was completed, the remaining HCl was quantitatively collected and titrated with 0.10 mol dm^{-3} NaOH. The burette reading at the end-point was 15.0 cm^3. The percentage of $CaCO_3$ in the wood ash sample **X** is

(1) 10% (2) 16% (3) 20% (4) 24% (5) 40%

30. Consider the equilibrium reaction given below.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ ($K_C = 50$ at temperature 600 °C)

Equal molar amounts of $H_2(g)$, $I_2(g)$ and HI(g) were inserted into a 2.0 dm^3 previously evacuated closed-rigid container at room temperature and the temperature was increased to 600 °C.
Which of the following will occur as the system reaches equilibrium?

(1) More $H_2(g)$ and $I_2(g)$ will be produced because $Q_C > K_C$ (Q_C = reaction quotient)
(2) Less $H_2(g)$ and $I_2(g)$ will be produced because $Q_C > K_C$
(3) More $H_2(g)$ and $I_2(g)$ will be produced because $Q_C < K_C$
(4) Less HI(g) will be produced because $Q_C < K_C$
(5) More HI(g) will be produced because $Q_C < K_C$

[See page seven

- For each of the questions **31** to **40**, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Which of the following statements is/are correct regarding the experiment for determination of the order of the reaction between $Fe^{3+}(aq)$ and $I^-(aq)$ (iodine-clock experiment)?

(*a*) The time taken to react a constant amount of $S_2O_3^{2-}(aq)$ is measured.
(*b*) The concentration of $S_2O_3^{2-}(aq)$ must be much higher than the concentration of $I^-(aq)$.
(*c*) $S_2O_3^{2-}(aq)$ cannot be used in the experiment determining the rate constant of the reaction between $Fe^{3+}(aq)$ and $I^-(aq)$.
(*d*) The concentration of $S_2O_3^{2-}(aq)$ must be much smaller than the concentration of $I^-(aq)$.

32. Which of the following statements is/are true regarding the reaction of 2-bromo-2-methylpropane with aqueous NaOH?

(*a*) It is an electrophilic substitution reaction.
(*b*) A carbocation is formed as an intermediate during the reaction.
(*c*) The major product formed is $(CH_3)_3COH$.
(*d*) $(CH_3)_2C{=}CH_2$ can be formed as a byproduct.

33. Which of the following reactions is/are correct?

(*a*) $CH_3\overset{O}{\overset{\|}{C}}OH \xrightarrow[(2)\ H^+/H_2O]{(1)\ CH_3MgBr} CH_3\overset{O}{\overset{\|}{C}}CH_3 + Mg(OH)Br$

(*b*) $CH_3CH_2\overset{CHO}{\overset{|}{C}}HCH_2OH \xrightarrow{CH_3MgBr} CH_3CH_2\overset{CH_3CHOMgBr}{\overset{|}{C}}HCH_2OH$

(*c*) $CH_3C{\equiv}CH \xrightarrow{CH_3MgBr} CH_3C{\equiv}CMgBr + CH_4$

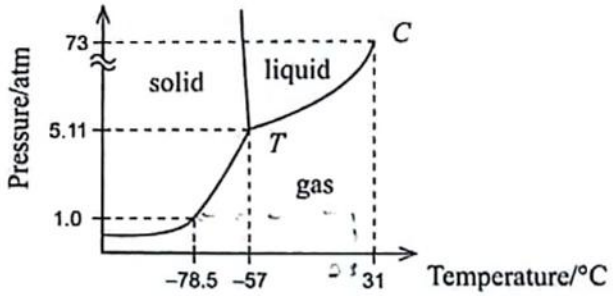
(*d*) $CH_3CH_2CH_2OH \xrightarrow{CH_3MgBr} CH_3CH_2CH_2OMgBr + CH_4$

34. Which of the following statements is/are true with regard to *s* and *p* block elements and their compounds?

(*a*) Be reacts with hydrogen gas to produce an ionic metal hydride.
(*b*) Mg has the highest electronegativity among *s*-block elements.
(*c*) NH_3, SO_2 and H_2S can act as oxidizing agents as well as reducing agents.
(*d*) Na and Ba react with excess oxygen gas when heated to give Na_2O_2 and BaO_2 respectively.

[*See page eight*

35. The phase-diagram of carbon dioxide (CO_2) is shown below.



It is observed that liquid CO_2 does not form when a sample of solid CO_2 (dry-ice) is placed in a beaker at 25 °C and 1 atm pressure. According to the above diagram which of the following statement/s explain/s this observation?

(*a*) The temperature at the triple-point is less than the critical temperature.
(*b*) The temperature at the critical point is higher than 25 °C.
(*c*) The pressure of the triple-point is higher than 1 atm.
(*d*) At 1 atm pressure solid CO_2 is in equilibrium only with the gas phase.

36. Which of the following statements is/are true?

(*a*) Following a systematic method of waste disposal contributes to minimize global warming.
(*b*) Minimizing deforestation contributes to increase global warming.
(*c*) NO gas emitted from transportation contributes to increase global warming.
(*d*) Coolant gases used in refrigerators and air-conditioners contribute to increase global warming.

37. Which of the following statements is/are true with regard to the function of the ozone layer in the stratosphere?

(*a*) NO_2 is required for the formation of ozone.
(*b*) Atomic oxygen produced in the troposphere produces ozone after reaching the stratosphere.
(*c*) Ozone level in the stratosphere fluctuates throughout the year.
(*d*) Infrared radiation is essential for the formation of ozone.

38. Consider the following cells.

A : $Zn(s) \mid Zn^{2+}(aq,\ 1.0\ mol\ dm^{-3}) \,\vdots\, Cu^{2+}(aq,\ 1.00\ mol\ dm^{-3}) \mid Cu(s)$

B : $Zn(s) \mid Zn^{2+}(aq,\ 1.0\ mol\ dm^{-3}) \parallel Cu^{2+}(aq,\ 1.00\ mol\ dm^{-3}) \mid Cu(s)$

(*a*) Ion migration occurs at both A and B.
(*b*) Mixing of electrolytes is prevented in both A and B.
(*c*) Ion migration occurs only in B.
(*d*) Mixing of electrolytes is prevented only in B.

39. Which of the following statements is/are correct regarding 3*d*-block elements and their compounds?

(*a*) The correct IUPAC name of $[Cr(NH_3)_6]Br_3$ is hexaamminechromium(III) tribromide.
(*b*) Based on the electronic configurations of the 3*d*-block metals, Zn is expected to have the lowest melting point.
(*c*) Cu shows the lowest stable oxidation state among 3*d*-block elements.
(*d*) CrO_3 dissolves in aqueous NaOH and gives $Cr_2O_7^{2-}$ ion.

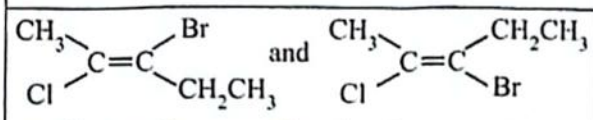
40. Which of the following statements is/are true regarding some industrial processes?

(*a*) The entropy change for the reaction of $N_2(g)$ with $H_2(g)$ to produce $NH_3(g)$ in the Haber-Bosch process is positive ($\Delta S > 0$).
(*b*) The reaction of $N_2(g)$ with $H_2(g)$ to produce $NH_3(g)$ in the Haber-Bosch process is an exothermic reaction.
(*c*) The industrial process for the production of high purity TiO_2 from rutile by chlorination followed by oxidation, results in the release of CO_2 to the environment.
(*d*) The reaction of $SO_2(g)$ with $O_2(g)$ to give $SO_3(g)$ in the contact process for producing sulphuric acid is an endothermic reaction.

[See page nine

- In question Nos. **41** to **50**, two statements are given in respect of each question. From the Table given below, select the response, out of the responses (1), (2), (3), (4) and (5), that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement
(2)	True	True, but does **not** explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	Metallic bonding in Group 1 elements (Li–Cs) is weaker than metallic bonding in Group 2 elements (Be–Ba).	Metallic bonding involves only one valence electron in Group 1 elements whereas two electrons are involved in Group 2 elements.
42.	 are diastereoisomers of each other.	Stereoisomers which are not mirror images of each other are diastereoisomers.
43.	When a few drops of dilute mineral acid are added to a 100 cm^3 solution of $CH_3NH_2(aq)$/ $CH_3NH_3Cl(aq)$, the pH of the solution does not change significantly.	A solution containing $CH_3NH_2(aq)$ and $CH_3NH_3Cl(aq)$ acts as a buffer solution.
44.	Aqueous solutions of Ni^{2+}, Cu^{2+} and Zn^{2+} when individually treated with excess $NH_4OH(aq)$ do not give permanent precipitates.	All three ions $Ni^{2+}(aq)$, $Cu^{2+}(aq)$ and $Zn^{2+}(aq)$ give ammine complexes when individually treated with excess $NH_4OH(aq)$.
45.	Benzene reacts with electrophilic reagents to give substitution products and not addition products.	The carbocation intermediate formed by the reaction between benzene and the electrophile is stabilized by the delocalization of its positive charge.
46.	In an electrochemical cell constructed by $Ag^+(aq)$/ $Ag(s)$ and $Cu^{2+}(aq)/Cu(s)$ electrodes, electrons flow from Cu to Ag. $E^\circ_{Cu^{2+}(aq)/Cu(s)} = 0.34$ V, $E^\circ_{Ag^+(aq)/Ag(s)} = 0.80$ V	In the electrochemical cell $Cu(s)\|Cu^{2+}(aq, 1\ M)\|Ag^+(aq, 1\ M)\|Ag(s)$, the $Cu^{2+}(aq)\|Cu(s)$ electrode is the cathode. $E^\circ_{Cu^{2+}(aq)/Cu(s)} = 0.34$ V, $E^\circ_{Ag^+(aq)/Ag(s)} = 0.80$ V
47.	$N_2(g)$ cannot behave as an oxidizing agent.	When heated $N_2(g)$ reacts with Li to give an ionic product which reacts with water liberating $NH_3(g)$.
48.	Addition of dilute $HNO_3(aq)$ to a saturated solution of PbC_2O_4 increases the solubility of $PbC_2O_4(s)$.	In the equilibrium $PbC_2O_4(s) \rightleftharpoons Pb^{2+}(aq) + C_2O_4^{2-}(aq)$, $C_2O_4^{2-}(aq)$, can be considered as the conjugate-base of $H_2C_2O_4(aq)$ acid.
49.	The amount of CO(g) produced by the reaction of coke and $O_2(g)$ in a blast furnace increases with increasing temperature.	The reaction between coke and $O_2(g)$ which produces CO(g) has a positive entropy change.
50.	Thermoset polymers cannot be softened by heating.	Thermoset polymers have a molecular structure arranged as a three dimensional network.

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கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2024
General Certificate of Education (Adv. Level) Examination, 2024

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

* Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$
* Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

PART B — ESSAY

Answer ***two*** *questions only.* (*Each question carries* **150** ***marks.***)

5. (*a*) A mixture of NO(g) and O_2(g) in 2:1 molar ratio respectively, was introduced to a rigid closed container of volume 10 dm^3 and allowed to react at temperature *T*. After a certain time, the system reached the equilibrium as given below, at temperature *T*.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

At equilibrium, the following observations were noted.

- The pressure of the gaseous mixture was $32 \times 8.314 \times 10^3$ Pa.
- The total number of moles of the three gases was 0.64.
- The mass of O_2 was 6.4 g.

(i) Calculate the concentration of each gaseous species in mol dm^{-3} at equilibrium. (O = 16)

(ii) Calculate the equilibrium constant, K_c at temperature *T*.

(iii) Calculate the value of temperature *T* (in K) under these conditions. State any assumption/s made.

(iv) Calculate the equilibrium constant K_p for the reaction,

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

at the temperature determined in (iii) above.

(70 *marks*)

(*b*) Consider the information given below at temperature 298 K.

$$\Delta H_f^{\circ}(NO(g)) = 90\ kJ\ mol^{-1}$$

$$\frac{1}{2}N_2(g) + O_2(g) \longrightarrow NO_2(g)\ \ \Delta H^{\circ} = 33\ kJ\ mol^{-1}$$

$$4NO_2(g) + O_2(g) \longrightarrow 2N_2O_5(g)\ \ \Delta H^{\circ} = -102\ kJ\ mol^{-1}$$

(i) Calculate ΔH° at temperature 298 K for the reaction,

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

(ii) Calculate $\Delta H_f^{\circ}(N_2O_5(g))$ at temperature 298 K.

(iii) Using the results obtained in (ii) above, predict the following.

I. the sign of $\Delta S_f^{\circ}(N_2O_5(g))$

II. spontaneity of the reaction for the formation of N_2O_5(g) from N_2(g) and O_2(g)

(80 *marks*)

[*see page ten*

6. (*a*) According to the kinetic molecular theory of gases, for an ideal gas at temperature T, $PV = \frac{1}{3}mN\overline{C^2}$. Here P is the pressure of the gas, V is the volume of the gas, m is the mass of a gas molecule, N is the number of molecules of gas and $\overline{C^2}$ is the mean square speed of the gas.

(i) Show that $\overline{C^2} = \frac{3RT}{M}$ for an ideal gas. M is the molar mass of the gas.

(ii) **A** and **B** are two ideal gases with molar masses M_A and M_B respectively. Show that the mean square speed of gas **B** $\left(\overline{C_B^2}\right)$ at temperature $T = 300\frac{M_B}{M_A}$, is equal to the mean square speed of gas **A** $\left(\overline{C_A^2}\right)$ at $T = 300$. (Temperatures are given in kelvin)

(iii) Derive an expression for the ratio between the molar kinetic energies of the two gases **A** and **B** at any given temperature T.

(40 *marks*)

(*b*) (i) Define the term 'an elementary reaction'.

(ii) Define the term 'molecularity' of a reaction.

(iii) For an elementary reaction what is the relationship between 'reaction order' and 'molecularity'?

(iv) The following table gives the variation of the concentration of the reactant in a reaction with time.

Time (minutes)	0	10	20	30	40
Reactant concentration (mol dm^{-3})	1.6	0.8	0.4	0.2	0.1

I. Determine the order of the reaction.

II. State the half-life of the reaction.

(v) Consider the information given below for two first order reactions ① and ② at a given temperature.

	Reaction	Reaction rate/ mol dm^{-3} s^{-1}	Rate constant/s^{-1}	Half-life/s
①:	$A \longrightarrow P_1$	r_A	k_A	$(t_{1/2})_A$
②:	$B \longrightarrow P_2$	r_B	k_B	$(t_{1/2})_B$

(P_1, P_2 = Products)

A first order reaction with rate constant, k has a half-life, $t_{1/2} = \frac{0.693}{k}$.

If $r_B = 3r_A$ when [B] = 2[A], show that $2(t_{1/2})_A = 3(t_{1/2})_B$.

(75 *marks*)

(*c*) At temperature 25 °C, 50.0 cm^3 of 0.30 g dm^{-3} iodine aqueous solution was shaken well with 10.0 cm^3 of CCl_4. When the system reached equilibrium the concentration of iodine in the water layer was found to be 0.02 g dm^{-3}.

(i) Calculate the concentration of iodine in the CCl_4 layer at equilibrium.

(ii) At temperature 25 °C, calculate the partition co-efficient of I_2 between CCl_4 and water.

(iii) If the above experiment was done at 25 °C with 20.0 cm^3 of CCl_4 instead 10.0 cm^3, calculate the concentration of iodine in the water layer at equilibrium.

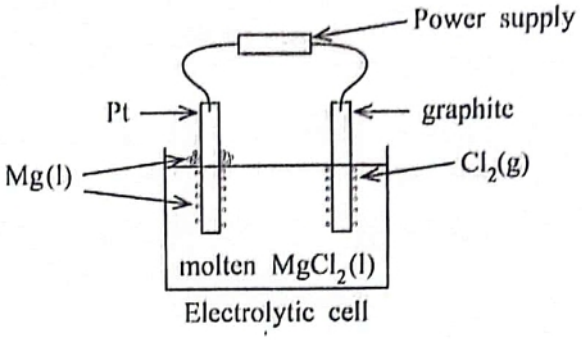
(35 *marks*)

[*see page eleven*

7.(*a*) Mg metal can be extracted by the electrolysis of molten $MgCl_2(l)$ using inert electrodes (examples :Pt, graphite). A simple setup for this is shown in the diagram.

$E^{\circ}_{Mg^{2+}(l)/Mg(s)} = -2.37$ V

$E^{\circ}_{H_2O(l)/H_2(g)} = -0.63$ V



Electrolytic cell

(i) Identify the anode and the cathode. Write the half reaction taking place at each electrode.

(ii) Write the overall cell reaction.

(iii) State the direction of electron flow through the external circuit as the cell operates.

(iv) Explain the following:

I. Molten $MgCl_2(l)$ is used instead of $MgCl_2(s)$ in this extraction process.

II. A solution of $MgCl_2(aq)$ cannot be used in this extraction process.

(v) If a 5.37 A current is passed through this cell for one hour and the $Cl_2(g)$ formed is collected at temperature 300 K and pressure 1 atm ($\sim 1.0 \times 10^5$ Pa), calculate the volume of $Cl_2(g)$ produced in dm^3. (1 F = 96 500 C)

(75 *marks*)

(*b*) (i) **P**, **Q**, **R**, **S** and **T** are coordination compounds of Co(III). They have an octahedral geometry. Give the structural formulae or draw the structures of these coordination compounds, selecting the appropriate species from the list given below.

Co^{3+}, K^+, NH_3, SO_4^{2-}, NO_2^-, Cl^-

Note : In the above coordination compounds NO_2^- behaves as a monodentate ligand when attached to the metal ion.

P – Only neutral ligands are coordinated to the metal ion. On reaction of an aqueous solution of **P** with dil. HCl, reddish-brown fumes are evolved. **P** gives four ions in aqueous solution.

Q – Two types of ligands are coordinated to the metal ion. They are neutral ligands and mono-atomic anionic ligands. A white precipitate insoluble in dilute acid is formed on addition of $BaCl_2(aq)$ to an aqueous solution of **Q**. **Q** gives two ions in aqueous solution.

R – Two types of ligands are coordinated to the metal ion. They are neutral ligands and multi-atomic anionic ligands. **R** shows geometric isomerism. On reaction of an aqueous solution of **R** with $AgNO_3(aq)$, a white precipitate is formed. This precipitate is soluble in dil. NH_4OH. **R** gives two ions in aqueous solution.

S – It is a non-ionic compound. An equal number of neutral ligands and multi-atomic anionic ligands are coordinated to the metal ion.

T – Only mono-atomic anionic ligands are coordinated to the metal ion. **T** gives four ions in aqueous solution.

(ii) I. Write the IUPAC name of **T**.

II. Draw the structures of the geometric isomers of **R**.

(iii) **X** is a coordination compound of Co(III) with an octahedral geometry. The ligands H_2O and CO_3^{2-} are coordinated to the metal ion. On treatment of an aqueous solution of **X** with $AgNO_3(aq)$ a pale yellow precipitate, soluble in conc. NH_4OH is formed. **X** gives two ions in aqueous solution. Give the structural formula or draw the structure of **X**.

Note : CO_3^{2-} coordinates to the metal ion through two oxygen atoms.

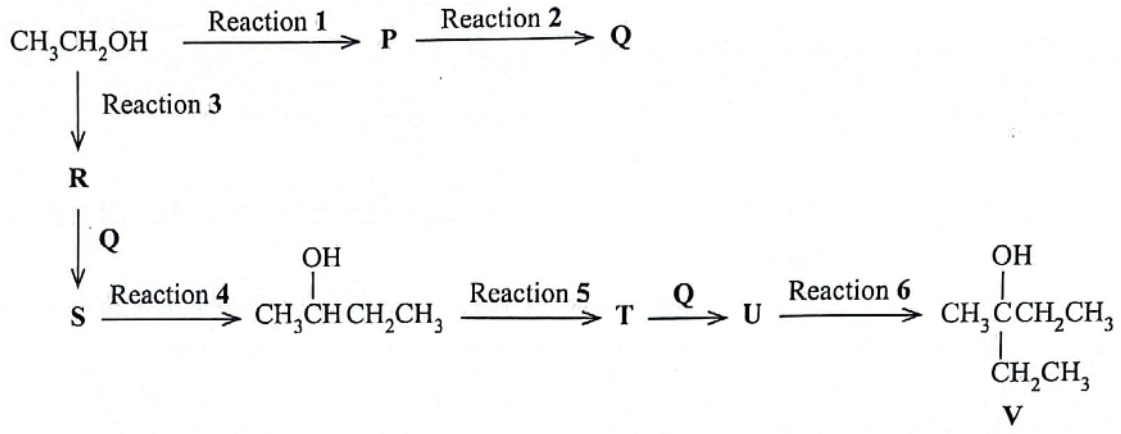
(75 *marks*)

[*see page twelve*

PART C — ESSAY

*Answer **two** questions only. (Each question carries **150** marks.)*

8. (*a*) Given below is a reaction scheme for the preparation of compound **V** using ethanol as the only organic starting material.

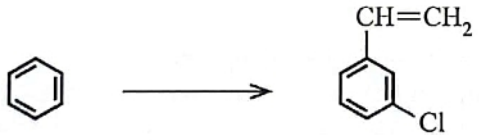


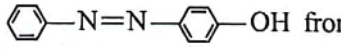
Complete the above reaction scheme by drawing the structures of compounds **P**, **Q**, **R**, **S**, **T** and **U** and writing the appropriate reagents for reactions **1 - 6** selected **only** from those given in the list below.

Reagents:
Dilute H_2SO_4, Mg/dry ether, PBr_3, Pyridinium chlorochromate (PCC)

(60 *marks*)

(*b*) (i) Show how you would carry out the following conversion in not more than **four (04)** steps.



(ii) Propose a method to prepare  from aniline in not more than **two (02)** steps.

(40 *marks*)

(*c*) (i) Write the product and the mechanism of the reaction that takes place between benzene and bromine in the presence of anhydrous $FeBr_3$.

(ii) Draw the resonance structures of benzene and aniline.

(iii) Considering the above resonance structures, explain why the benzene nucleus in aniline is more reactive towards electrophilic substitution reactions than benzene itself.

(iv) Draw the structure of the product formed when aniline reacts with bromine.

(50 *marks*)

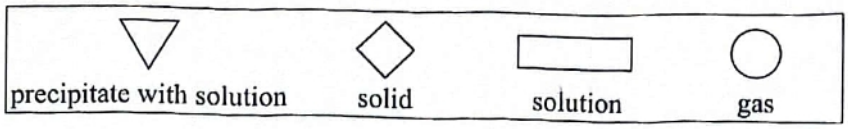
[*see page thirteen*

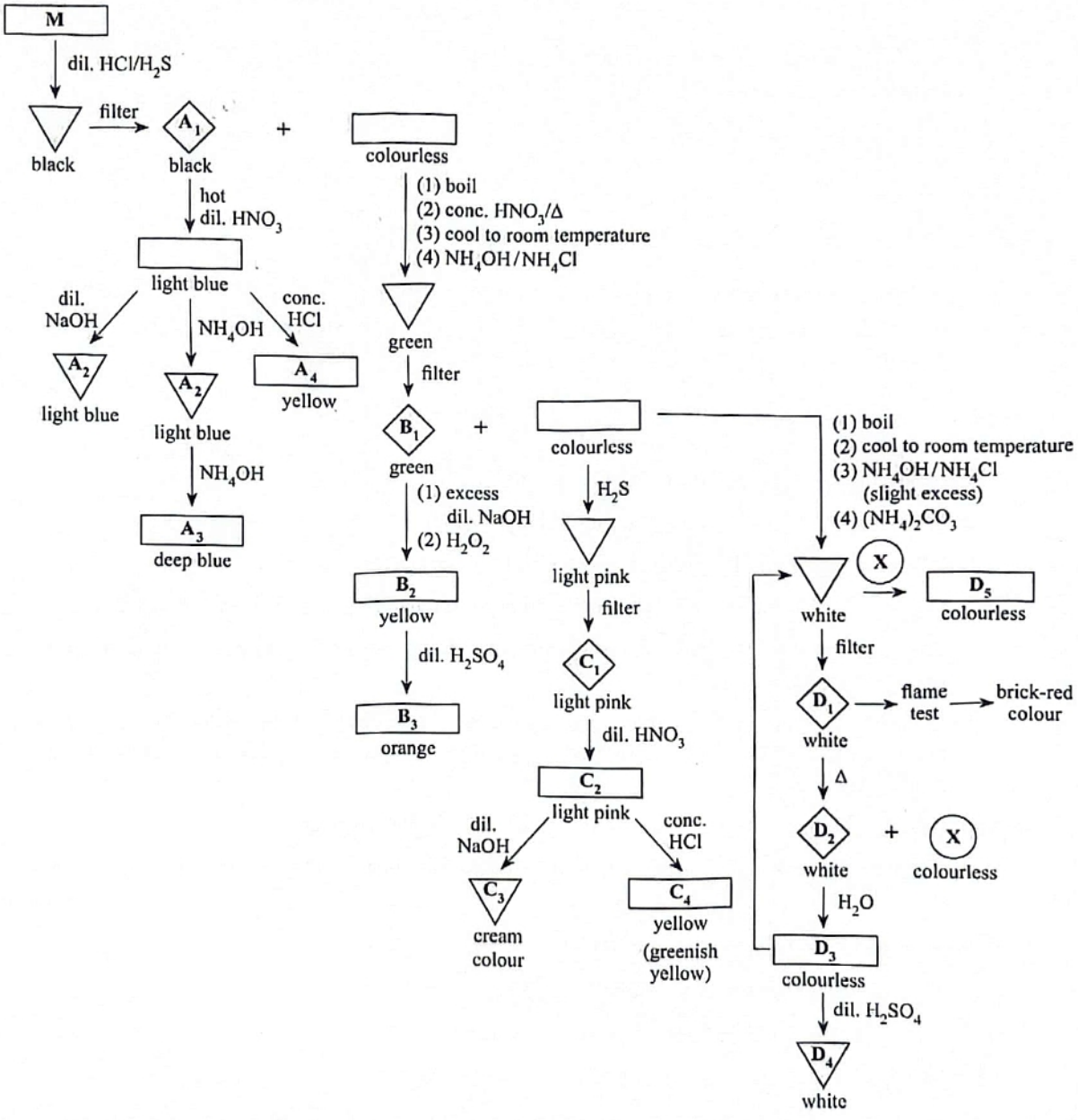
9. (*a*) The following question is based on the qualitative analysis of cations.

An aqueous solution **M** contains one cation of each of the metals **A**, **B**, **C** and **D**.

M is analysed according to the scheme given below.

The symbols given in the box are used to represent precipitate with solution, solids, solutions and gases.





A_1–A_4, B_1–B_3, C_1–C_4 and D_1–D_5 are compounds/species of the four cations of metals **A**, **B**, **C** and **D**. **X** is a gas.

Identify A_1, A_2, A_3, A_4, B_1, B_2, B_3, C_1, C_2, C_3, C_4, D_1, D_2, D_3, D_4, D_5, and **X**.

(**Note** : Write **only** chemical formulae. Chemical equations and reasons are **not** required.)

(75 *marks*)

[*see page fourteen*

(*b*) The main compound present in iron pyrite is FeS_2. A 1.50 g sample of iron pyrite was oxidized under laboratory conditions and all the sulphur in FeS_2 was converted to SO_4^{2-}. The resultant SO_4^{2-} was precipitated as $BaSO_4$. The dry weight of $BaSO_4$ obtained was 4.66 g.

(i) Calculate the weight percentage of FeS_2 present in iron pyrite.

FeS_2 in 20.0 g of iron pyrite was subjected to oxidation by soil microbes under natural conditions for 120 hours.

This oxidation reaction is represented in the following equation.

$$4FeS_2(s) + 15O_2(g) + 14H_2O(l) \xrightarrow{\text{soil microbes}} 4Fe(OH)_3(s) + 8H_2SO_4(aq)$$

H_2SO_4 that was produced in this reaction after 120 hours was quantitatively separated and precipitated as $BaSO_4$. The dry weight of $BaSO_4$ obtained was 31.13 g.

(ii) Calculate the percentage conversion of FeS_2 in iron pyrite to SO_4^{2-} after 120 hours by soil microbes.

Note : Percentage conversion $= \dfrac{\text{Experimentally obtained mass using soil microbes}}{\text{Theoretical mass}} \times 100$

(iii) Calculate the amount of iron pyrite required to produce 8 kg of H_2SO_4 by soil microbes when the conversion percentage of FeS_2 in iron pyrite to SO_4^{2-} is 100%.
(Relative atomic mass : O = 16, S = 32, Fe = 56, Ba = 137)

(75 *marks*)

10. (*a*) The following questions are based on the Solvay process.

(i) What is the main product of the Solvay process?

(ii) What is the main by-product of the Solvay process?

(iii) What are the raw materials (starting materials) used in the Solvay process?

(iv) Which one of these raw materials in (iii) above is not consumed in the process but is recycled repeatedly?

(v) Identify the first step of the Solvay process in which raw materials are mixed inside a tower which consists of perforated clay trays. Explain why this is carried out at a low temperature.

(vi) Give **three** uses of the main product of the Solvay process.

(vii) Give **three** reasons contributing to the economic profitability of the Solvay process.

(50 *marks*)

(*b*) Briefly explain each of the following statements.

(i) Agriculture contributes to global warming.

(ii) Iron extraction contributes to global warming.

(iii) Transportation contributes to photochemical smog.

In your answer indicate how the chemical species responsible for the given environmental effect in each of the statements above is/are formed.

(50 *marks*)

[*see page fifteen*

(c) (i) The following questions are based on vinegar production.

I. State what is the process used in the production of natural vinegar.

II. Write the name of the active chemical ingredient present in natural vinegar.

III. Name the titrant and the indicator used in the quantitative determination of the active chemical ingredient in natural vinegar.

IV. State the difference in composition between natural vinegar and artificial vinegar.

(ii) The following questions are based on the extraction of essential oils from plants.

I. Name **three** methods that can be used to extract essential oils.

II. State which of the above methods is based on the application of Daltons Law of partial pressures.

III. Name the major compound present in each of the essential oils given below.

- Citronella oil
- Cinnamon root oil
- Cinnamon leaf oil

(50 *marks*)

* * *

[*see page sixteen*