ANDERSON SERANGOON JUNIOR COLLEGE

2024 JC 2 PRELIMINARY EXAMINATION

NAME:__________________________ ( ) **CLASS:** 24 / ___

CHEMISTRY **8873/01**

Paper 1 Multiple Choice **17 September 2024**

1 hour

Additional Materials: Multiple choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Multiple Choice Answer Sheet

Write your name, class and NRIC / FIN number, **including** the reference letter.

Shade the NRIC / FIN number.

Exam Title: JC2 Preliminary Exam

Exam Details: H1 Chemistry / Paper 1

Date: 17/09/2024

This document consists of __ printed pages.

1 *Use of the Data Booklet is relevant to this question.*

A proton and a helium nucleus both move at the same speed perpendicular to a uniform electric field.

Which row describes the behaviour of the proton and the helium nucleus?

A They are deflected in opposite directions. The helium nucleus is deflected most.

B They are deflected in opposite directions. The proton is deflected most.

C They are deflected in the same direction. The helium nucleus is deflected most.

D They are deflected in the same direction. The proton is deflected most.

Answer: **D**

Proton is $^{1}H^{+}$. Helium nucleus is $^{4}He^{2+}$.

NOT A and B

Both are positively charged so they are deflected in the same direction towards the negatively charged plate.

NOT C

Proton ($^{1}H^{+}$) is deflected most.

	$^{1}H^{+}$	$^{4}He^{2+}$
$\left(\frac{\text{charge}}{\text{mass}}\right)$ ratio	1	½

Angle of deflection is proportional to $\frac{\text{charge}}{\text{mass}}$ ratio.

Angle of deflection of $^{1}H^{+}$ is twice that of $^{4}He^{2+}$.

2 Which of these atomic orbitals possesses the highest relative energy?

A $2p_z$

B $3p_x$

C $3p_y$

D 4s

Answer: **D**

The 4th quantum number possesses larger relative energies as compared to 2nd and 3rd quantum shells.

3 The 7th, 8th, 9th and 10th ionisation energies of an element are shown.

7th ionisation energy / kJ mol^{-1}	8th ionisation energy / kJ mol^{-1}	9th ionisation energy / kJ mol^{-1}	10th ionisation energy / kJ mol^{-1}
9941	18 580	21 610	25 180

Which group does this element belong to?

A 15 **B** 16 **C** 17 **D** 18

Answer: **C**

Largest difference in ionisation energy (IE) is between the 7th and 8th electron removed, indicating 7 valence electrons and the 8th electron is removed from an inner quantum shell. Thus, the element is from Group 17.

4 Silicon carbide, SiC, is a shiny, hard, chemically inert material with a very high melting point. It can be used to sharpen knives and make crucibles.

Which type of structure does silicon carbide have?

A a giant structure with covalent bonds between silicon and carbon atoms

B a giant structure containing strong electrostatic forces of attraction between oppositely charged ions

C a giant layered structure with covalent bonds between atoms and instantaneous dipole – induced dipole forces between layers

D a simple molecular structure with covalent bonds between the atoms of silicon and carbon

Answer: **A**

A Correct. Strong covalent bonds between the non-metallic atoms in an extensive 3-dimensional network.

B Incorrect. Silicon and carbon are non-metallic elements. Moreover, giant ionic compounds tend to be brittle and unable to be used to sharpen knives and crucibles.

C Incorrect. This is the description for graphite. The instantaneous dipole – induced dipole forces will cause the layers to slip over one another and the resultant compound is not expected to be hard.

D Incorrect. Simple molecules have weak intermolecular forces of attraction and which are easily broken.

5 Compared with the HC*l* molecule, the bond ….**X**….. of the HI molecule is ….**Y**…..

Which pairs of words correctly complete the above sentence?

	X	**Y**
1	energy	greater
2	length	longer
3	polarity	lower

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

Answer: **C**

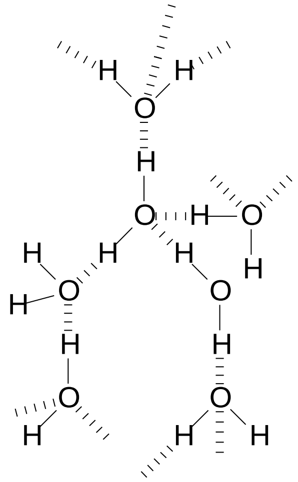
- Size of valence orbitals: I > C*l*
- Valence orbitals of I are more diffused than that of C*l*
- Overlap of orbitals is less effective in H–I than in H–C*l*
- H−I bond is weaker than H−C*l* bond

Hence, bond energy: H−I $\leq$ H–C*l*; bond length: H−I $\geq$ H–C*l*

- Electronegativity: I < C*l*

Hence, H−I bond is less polar than H–C*l* bond

6 The diagram below shows the structure of part of a crystal of ice.



Which statement is correct?

A All the bond angles surrounding each oxygen atom are 120°.

B Four electrons from each oxygen are involved in forming hydrogen bonds.

C The hydrogen bonds, shown by the dotted lines, are stronger than the O–H covalent bonds.

D The open structure of ice causes ice to be denser than water.

Answer: **B**

Option **A** is incorrect as all the bond angles surrounding each O atom are 109.5^{o} (tetrahedral).

Option **B** is **correct** as 2 lone pairs (total 4 electrons) on each O atom are used to form H-bonds with H from neighboring H_2O molecules.

Option **C** is incorrect as hydrogen bonds are weak intermolecular forces compared to covalent bonds which are stronger.

Option **D** is incorrect as open structure i.e. lots of empty space between molecules is the reason why the density of ice is lower than that of water.

7 The ionic product of water, K_w, is affected by temperature.

Temperature / °C	$K_w \times 10^{-14}$ / mol^2 dm^{-6}
10	0.293
40	2.92

Which statement describes what happens as the temperature of water is increased from 10 °C to 40 °C?

A pH of water decreases and $[H^+] = [OH^-]$.

B pH of water decreases and $[H^+]$ is greater than $[OH^-]$.

C pH of water increases and $[H^+] = [OH^-]$.

D pH of water increases and $[H^+]$ is less than $[OH^-]$.

Answer: **A**

$H_2O \rightleftharpoons H^+ + OH^- \quad \Delta H > 0$
$K_w = [H^+][OH^-]$

When temperature of water increases, K_w also increases. This shows that the position of equilibrium has shifted to the right and more H^+ and OH^- ions are produced.

$pH = -\log_{10}[H^+]$
$\therefore$ pH of water decreases

Since the stoichiometric coefficients of H^+ and OH^- ions are equal in the above equation, the increase in the number of H^+ and OH^- ions will be the same.
$\therefore [H^+] = [OH^-]$

8 25.0 cm^3 of 0.100 mol dm^{-3} phosphoric acid, H_3PO_4, is titrated against 0.100 mol dm^{-3} NaOH. The following pH value is recorded.

Volume of NaOH added/ cm^3	pH
25.00	4.70

The table below shows the pH range for colour change for some acid-base indicators.

indicator	range of pH for colour change
bromocresol green	3.8 – 5.4
phenol red	6.8 – 8.4
phenolphthalein	8.3 – 10.0

Which indicator can be used to identify the titration end-point?

A Phenolphthalein

B Bromocresol green

C Phenol red

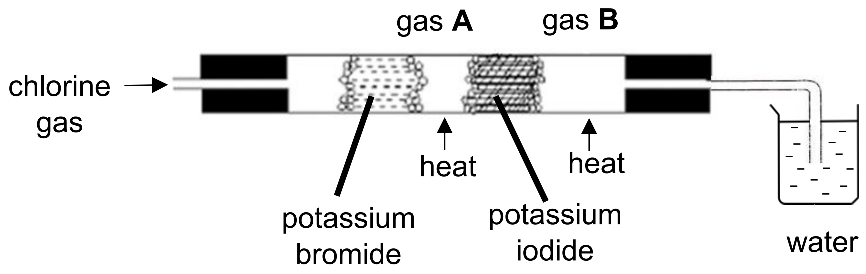
D There is no suitable indicator.

Answer: **B**

Based on the equivalence point pH value, the suitable indicator is bromocresol green as the pH at equivalence point for the titration occurs within the working pH range of the indicator.

9 *Use of the Data Booklet is relevant to this question.*

Using the apparatus shown, chlorine gas was passed through the tube. After a short time, some observable changes were seen during the experiment.



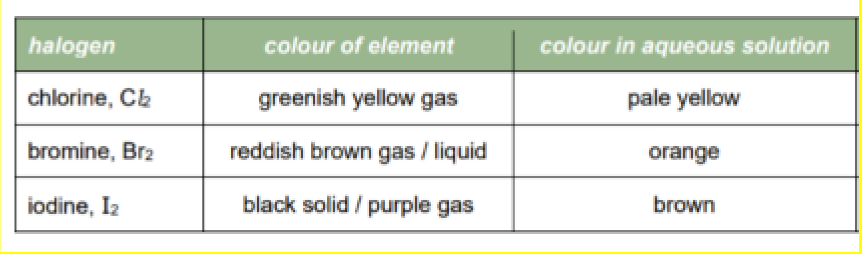
What are the colours observed for gas **A,** gas **B** and of the water in the beaker during the experiment?

	Colour of gas **A**	Colour of gas **B**	Colour of water in the beaker
A	reddish-brown	brown	purple
B	reddish-brown	purple	brown
C	colourless	purple	colourless
D	brown	brown	orange

Answer: **B**

Reactivity and oxidising power decreases down Group 17.
$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ (reddish-brown gas)
$Br_2 + 2I^- \rightarrow 2Br^- + I_2$ (purple gas, dissolves in water to form brown solution)

Data Booklet:



halogen	*colour of element*	*colour in aqueous solution*
chlorine, Cl_2	greenish yellow gas	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange
iodine, I_2	black solid / purple gas	brown

10 How do the properties for Group 1 elements and their ionic compounds change down the group?

	Reducing Power	Ionisation Energy	Strength of ionic bonding in Group 1 oxides
A	increases	increases	increases
B	decreases	increases	decreases
C	increases	decreases	increases
D	increases	decreases	decreases

Answer: **D**

Reducing Power: Down Group 1,

- **Number of electron shells increase**, which result in **valence electron further away and is more shielded** from the nucleus**.**
- There are **weaker electrostatic forces of attraction between the nucleus and the valence electrons**.
- Thus, **ability of M to lose electrons (get oxidised) increases**
- **reducing power increases.**

Ionisation Energy:

- **Nuclear charge increases**
- However, **number of electron shells increase**, which result in **valence electron further away and is more shielded** from the nucleus**.**
- **Less energy** is required to overcome the **weaker** (electrostatic) **forces of attraction** between the nucleus and the valence electron to be removed.
- First ionisation energies **decrease** down the group.

Strength of ionic bonding in Group 1 oxides: Down the group, the ion has 1 additional filled electronic shell and hence bigger ionic radius. The magnitude of L.E i.e. $\left|\frac{q^+q^-}{r^+ + r^-}\right|$ is dependent on the strength of ionic bonding. As r^+ increases when q^+, q^- and r^- remain the same, the magnitude of LE decreases, resulting in weaker ionic bonds in the group 1 oxides down the group.

11 Element **X** is in Period 3 of the Periodic Table. The following four statements were made about the properties of element **X** or its compounds.

Three statements are correct descriptions. One of the statements is not correct because it does not fit with the other three.

Which statement is **not** correct?

A Element **X** forms a chloride **X**Cl_3, which reacts with more chlorine to give **X**Cl_5.

B Element **X** is a solid at room temperature.

C The oxide of **X** reacts with water to give an acidic solution.

D Adding NaOH(aq) to the solution resulting from the reaction of **X**Cl_5 with water produces a white precipitate which is soluble in an excess of NaOH(aq).

Answer: **D**

Element X can be deduced to be phosphorus.

A. $PCl_3 + Cl_2 \longrightarrow PCl_5$

B. P_4 is a solid at room temperature.

C. P_4O_{10} is a covalent oxide that can undergo hydrolysis to give H_3PO_4.

$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

D: $PCl_5 + 3H_2O \longrightarrow H_3PO_4(aq) + 5HCl(aq)$

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

$3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$

(White ppt is not produced)

12 *Use of the Data Booklet is relevant to this question.*

Gallium is widely used to make alloys.

From its position in the Periodic Table, which properties will it be expected to possess?

1 In the vapour phase, the chloride has the formula Ga_2Cl_6.

2 Its oxide dissolves in aqueous acid.

3 Its oxide dissolves in aqueous base.

4 It has a giant molecular structure.

A 1, 2 and 3 only **B** 3 and 4 only **C** 1 and 2 only **D** 4 only

Answer: **A**

Ga is a Group 13 element.

Comparing the chemical properties of Ga with a familiar Group 13 element, A*l*, the following deductions can be made:

Option 1 is correct. Like $AlCl_3$, $GaCl_3$ dimerises in the vapour phase to form Ga_2Cl_6.

Option 2 and 3 are correct. Like Al_2O_3, the amphoteric oxide of Ga can dissolve in aqueous acid and base.

Option 4 is incorrect. Ga has a giant metallic structure.

13 *Use of the Data Booklet is relevant to this question.*

Which statement is correct?

A 1 mol of ethane contains 6 mol of atoms.

B 1 mol of deuteride, $^{2}H^{-}$, contains 2 g of neutrons.

C 148.3 g of magnesium nitrate contains 2 x 6.02 × 10^{23} ions.

D 135.8 dm^3 of neon gas, ^{20}Ne, measured at s.t.p., contains 3.6 x 10^{25} electrons.

Answer: **D**

A: Ethane, CH_3CH_3 has 8 atoms. Ethene, $CH_2{=}CH_2$, has 6 atoms.

B: 1 mole of $^{2}H^{-}$ (1p, 1n, 2e) weighs 2g. Since protons and neutrons have the same relative mass, 1 mole of $^{2}H^{-}$ would contain 1g of protons and 1g of neutrons.

C: Amt of $Mg(NO_3)_2$ = 148.3 / 148.3 = 1 mol
1 mol $Mg(NO_3)_2$ contains 3 mol of ions (Mg^{2+} and 2 NO_3^-) and hence 3 x 6.02 x 10^{23}
= 1.81 x 10^{24} ions

D: Amt of Ne atoms = $\frac{135.8}{22.7} = 5.98$ mol
One Ne atom has 10p, 10e and 10n.
Amt of electrons = 5.98 x 6.02 x 10^{23} x 10 = 3.60 x 10^{25}

14 10 cm^3 of a gaseous hydrocarbon was completely burnt in 100 cm^3 of oxygen. The volume of residual gas obtained was 80 cm^3. When the residual gas was shaken with aqueous potassium hydroxide, its volume decreased by 60 cm^3.

Which of the following is the molecular formula of the hydrocarbon? All volumes are measured at room temperature and pressure.

A C_3H_4 **B** C_3H_8 **C** C_6H_6 **D** C_6H_8

Answer: **D**

	C_xH_y	+	$(x + y/4)O_2 \rightarrow$	xCO_2	+	$y/2H_2O$
Initial vol	10		100	0		
Final vol	0		20	60		

At r.t.p, water is a liquid and hence is not considered a 'residual gas'. The 80 cm^3 of residual gas consists of CO_2 formed and excess (unreacted) O_2. 60 cm^3 of the mixture reacted with KOH which means 60 cm^3 of the mixture comprises of CO_2. Hence (80 – 60 = 20 cm^3) is excess (unreacted) oxygen.

Vol of O_2 used in the combustion = 100 – 20 = 80 cm^3
Hence, 10 cm^3 of C_xH_y reacted with 80 cm^3 of O_2 and produced 60 cm^3 of CO_2
So, $C_xH_y \equiv 8O_2 \equiv 6CO_2$

By inspection, $C_xH_y + 8O_2 \rightarrow 6CO_2 + 4H_2O$
Hence x = 6 and y = 2 x 4 = 8
C_xH_y is C_6H_8

15 In leaded petrol, there is an additive composed of lead, carbon and hydrogen only. This compound contains 29.7% carbon and 6.19% hydrogen by mass.

What is the empirical formula of the compound?

A PbC_3H_6

B PbC_8H_{10}

C $PbC_{10}H_{20}$

D PbC_8H_{20}

Answer: **D**

	Pb	C	H
%	64.11	29.7	6.19
A_r	207.2	12	1
$\%/A_r$	0.30941	2.475	6.19
Ratio	1	8	20

16 Mercurous chloride, Hg_2Cl_2, decomposes upon exposure to ultraviolet light as shown below.

$$Hg_2Cl_2 \longrightarrow HgCl_2 + Hg$$

Which of the following statements regarding this reaction are correct?

1 Hg_2Cl_2 is reduced to Hg.

2 Hg in $HgCl_2$ has an oxidation state of +2.

3 There is no change to the oxidation state of C*l*.

A 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 1 only

Answer: **A**

1 Hg_2Cl_2 is reduced to Hg.
⇒True. O.S. of Hg decreased from +1 in Hg_2Cl_2 to 0 in Hg, thus Hg is reduced.

2 Hg in $HgCl_2$ has an oxidation state of +2.
⇒True. Cl has O.S. of –1, thus Hg has O.S. of +2.

3 There is no change to the oxidation state of C*l*.
⇒True. O.S. of C*l* remained as –1 in both $HgCl_2$ and Hg_2Cl_2.

17 0.001 mol of a gaseous oxide, **Y**O_x, reacted exactly with 50 cm^3 of 0.02 mol dm^{-3} acidified potassium manganate(VII) solution.

Given that the oxidation state of **Y** in the product is +6, what is the initial oxidation state of **Y** in **Y**O_x?

[x can be any integer]

A +1 **B** +2 **C** +3 **D** +4

Answer: **A**

Amount of MnO_4^- used = $\frac{50}{1000}$ × 0.020 = 1 ×10^{-3} mol

$MnO_4^- + 5e + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

Amt of electrons gained during [R] = 1×10^{-3} × 5
= 0.005 mol
= Amt of electrons released during [O]

Amount of YO_x used = 0.001 mol

Amt of electrons released per mole of YO_x used = 0.005/0.001 = 5 mol

Let n be the initial oxidation no. of Y in YO_x

$Y^{n+} \rightarrow Y^{6+} + 5e$

n = 1, i.e. the initial O.N. of Y is **<u>+1</u>**

18 The enthalpy change of formation of solid potassium chloride can be calculated by considering some of the following enthalpy changes shown in the table.

	Enthalpy change / kJ mol^{-1}
$K(s) \longrightarrow K(g)$	+90
$Cl_2(g) \longrightarrow 2Cl(g)$	+242
$K(g) \longrightarrow K^+(g) + e^-$	+418
$Cl(g) + e^- \longrightarrow Cl^-(g)$	–355
$Cl(g) \longrightarrow Cl^+(g) + e$	+1260
$K^+(g) + Cl^-(g) \longrightarrow KCl(s)$	–710

What is the enthalpy change of formation of KC*l*(s)?

A –155 kJ mol^{-1}

B –436 kJ mol^{-1}

C +824 kJ mol^{-1}

D +945 kJ mol^{-1}

Answer: **B**

ΔH_f is defined as the amount of energy involved when 1 mole of the compound is formed from its constituent elements in their standard states i.e. for KCl(s),

$$K\,(s) + \tfrac{1}{2}\,Cl_2\,(g) \longrightarrow KCl\,(s)$$

	Enthalpy change / kJ mol^{-1}
$K\,(s) \longrightarrow \cancel{K}\,(g)$	+90
$\tfrac{1}{2}\,Cl_2\,(g) \longrightarrow 1\,\cancel{Cl}\,(g)$	½ (+242)
$\cancel{K}\,(g) \longrightarrow \cancel{K^+}\,(g) + \cancel{e^-}$	+418
$\cancel{Cl}\,(g) + \cancel{e^-} \longrightarrow \cancel{Cl^-}\,(g)$	-355
~~$Cl\,(g)$~~ $\longrightarrow$ ~~$Cl^+\,(g) + e$~~	~~+1260~~ (irrelevant)
$\cancel{K^+}\,(g) + \cancel{Cl^-}\,(g) \longrightarrow KCl\,(s)$	-710

Adding up all the relevant equations and their enthalpy change values,

$$\Delta H_f = 90 + 121 + 418 + (-355) + (-710)$$
$$= \underline{-436\text{ kJ mol}^{-1}}$$

19 A student mixed 25.0 cm^3 of 1.50 mol dm^{-3} ethanedioic acid, $(COOH)_2$ with an equal volume of 3.00 mol dm^{-3} sodium hydroxide.

$$\tfrac{1}{2}\,(COOH)_2 + NaOH \longrightarrow \tfrac{1}{2}\,(COO^-Na^+)_2 + H_2O$$

The initial temperature of both solutions was 15.0 °C. The maximum temperature recorded was 25.0 °C. It was found that 15 % of the heat produced during the experiment was lost to the surroundings.

Assume that the specific heat capacity of the solution is 4.18 J g^{-1} $^oC^{-1}$ and that the density of the solution is 1.00 g cm^{-3}.

Using these results, what is the enthalpy change of neutralisation in kJ mol^{-1}?

A $-\dfrac{(50)(1)(4.18)(10)(0.85)}{(37.5)}$

B $-\dfrac{(50)(1)(4.18)(10)(0.85)}{(75)}$

C $-\dfrac{(50)(1)(4.18)(10)}{(0.85)(75)}$

D $-\dfrac{(50)(1)(4.18)(373)(0.15)}{(75)}$

Answer: **C**

Amt of $(COOH)_2 = \dfrac{25.0}{1000} \times 1.50 = 0.0375$ mol

Amt of NaOH $= \dfrac{25.0}{1000} \times 3.00 = 0.07500$ mol

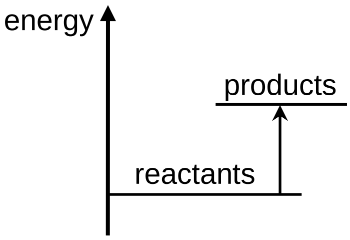
Amt of water formed = Amt of NaOH = 0.07500 mol

$\Delta T = 25 - 10 = 10\ ^oC$

heat produced $= (25.0 + 25.0) \times 1 \times 4.18 \times 10 \times \dfrac{100}{85}$

$$\Delta H_n = -\frac{Q}{n_{H_2O}} = -\frac{(50)(1)(4.18)(10)(\frac{100}{85})}{0.07500}\ \text{J mol}^{-1} = -\frac{(50)(1)(4.18)(10)}{(0.85)(75)}\ \text{kJ mol}^{-1}$$

20 Which of the following equations could have the energy level diagram shown?



A $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

B $NaF(s) \rightarrow Na^+(g) + F^-(g)$

C $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

D $H(g) + F(g) \rightarrow HF(g)$

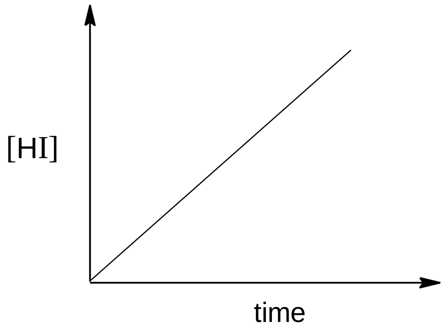
Answer: **B**

The energy diagram shows an endothermic reaction.
Option A is a neutralisation reaction which is exothermic.
Option B is the reverse of lattice energy for NaF(s), which is an endothermic reaction.
Option C is a combustion reaction which is exothermic.
Option D shows bond formation of H–F bonds, which is an exothermic reaction.

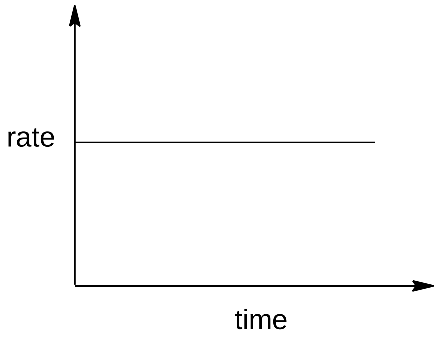
21 The decomposition of HI is a second order reaction.

Which graph correctly describes the kinetics of this reaction?

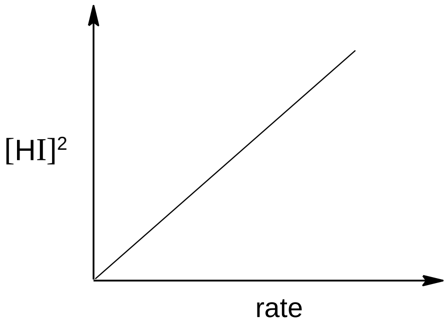
A



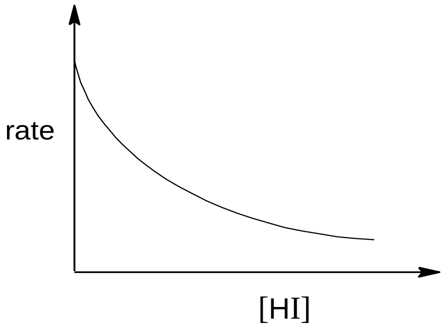
B



C



D

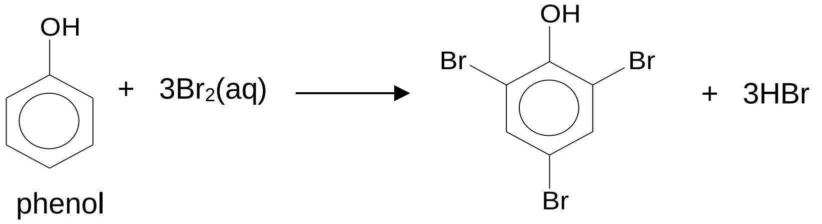


Answer: **C**

Since reaction is second order with respect to HI, rate = $k[HI]^2$ and rate is directly proportional to $[HI]^2$.
The graph of $[HI]^2$ against rate will be an upward sloping straight line passing through the origin.

22 The initial rate of the slow reaction between potassium bromate(V), $KBrO_3$ and potassium bromide, KBr under acidic conditions can be studied using phenol. The equations for the reactions are as follows.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l) \qquad \text{reaction 1}$$



reaction 2

A small amount of phenol and three drops of methyl red indicator was added into each experiment mixture to study the progress of reaction. The bromine produced by reaction 1 will immediately react with phenol in reaction 2, until all the phenol is consumed. Any additional bromine that is produced will bleach the indicator completely. The time taken, t, for the complete disappearance of the red colour of the indicator is measured.

Expt no	Volume of $KBrO_3$ / cm^3	Volume of KBr / cm^3	Volume of HC*l* / cm^3	Volume of phenol / cm^3	Volume of water / cm^3	Time, t / s
1	5	25	30	2	40	80
2	5	25	60	2	10	20
3	10	25	60	2	5	10
4	5	50	15	2	30	160

Which of the following statements is correct?

A The order of reaction with respect to H^+ is 1.

B The overall order of reaction is 3.

C The units of the rate constant are $mol^{-3}\,dm^9\,s^{-1}$.

D Increasing the concentration of phenol added will result in a smaller value of t.

Answer: **C**

Since the total volume of the reaction mixture for expt 1 to expt 4 is kept constant at 100 cm^3, the initial [reactant] in the reaction mixture is directly proportional to volume of reactant used.

t is the time take for the complete disappearance of the indicator i.e. the time taken for a fixed and small amount of Br_2 to be formed in reaction 1. Since the reaction proceeded to the same extent for expt 1 to expt 4, initial rate is directly proportional to $\frac{1}{t}$.

Expt no	Volume of $KBrO_3$ / cm^3	Volume of KBr / cm^3	Volume of HC*l* / cm^3	Volume of phenol / cm^3	Volume of water / cm^3	Time, t / s	1/t / s^{-1}
1	5	25	30	2	40	80	0.01250
2	5	25	60	2	10	20	0.05000
3	10	25	60	2	5	10	0.10000

4	5	50	15	2	30	160	0.00625

To determine the order of reaction w.r.t. HC*l*:
Compare Experiment 1 and 2, when [HC*l*] doubles, rate increases by a factor of 4. Since rate is directly proportional to $[\text{HC}l]^2$, the reaction is **second order** with respect to H^+. (Option **A** is incorrect)

To determine the order of reaction w.r.t. BrO_3^-:
Compare Experiment 2 and 3, when $[BrO_3^-]$ doubles, rate doubles. Since rate is directly proportional to $[BrO_3^-]$, the reaction is **first order** with respect to BrO_3^-.

Let the order of reaction w.r.t. Br^- be x.
Rate = $k[Br^-]^x[BrO_3^-][\text{HC}l]^2$

To determine the order of reaction w.r.t. Br^-,
Compare Experiment 1 and 4,

$$\frac{\text{rate } 4}{\text{rate } 1} = \frac{k(50)^x(5)^1(15)^2}{k(25)^x(5)^1(30)^2}$$

$$\frac{0.00625}{0.01250} = \frac{(2)^x}{(1)^x}\left(\frac{1}{2}\right)^2$$

$$2 = (2)^x$$
$$x = 1$$

The reaction is **first order** with respect to Br^-.

$$\text{rate} = k[Br^-][BrO_3^-][H^+]^2$$

$$\text{units of k} = \frac{\text{units of rate}}{\text{units of } [Br^-][BrO_3^-][H^+]^2}$$

$$= \frac{\text{mol dm}^{-3}\text{ s}^{-1}}{(\text{mol dm}^{-3})^4}$$

units of k = $\underline{\text{mol}^{-3}\text{dm}^9\text{s}^{-1}}$ (Option **C** is correct)

Overall order of reaction = 4 (Option **B** is incorrect)

Option **D** is incorrect. Increasing the concentration of phenol added means more moles of phenol is added. This means more Br_2 will need to be produced to react with the increased amount of Br_2 before the disappearance of the red colour is observed. Hence, t will be larger.

23 The equation for a reversible reaction is shown below. The addition of a catalyst **W** increases the rates of both the forward and reverse reactions.

$$\mathbf{X}(g) \rightleftharpoons \mathbf{Y}(g) \qquad \Delta H = +21 \text{ kJ mol}^{-1}$$

The activation energy of the uncatalysed forward reaction is higher than that of the catalysed forward reaction by 78 kJ mol^{-1}.

The activation energy for the uncatalysed reverse reaction is 163 kJ mol^{-1}.

What is the activation energy of the catalysed forward reaction?

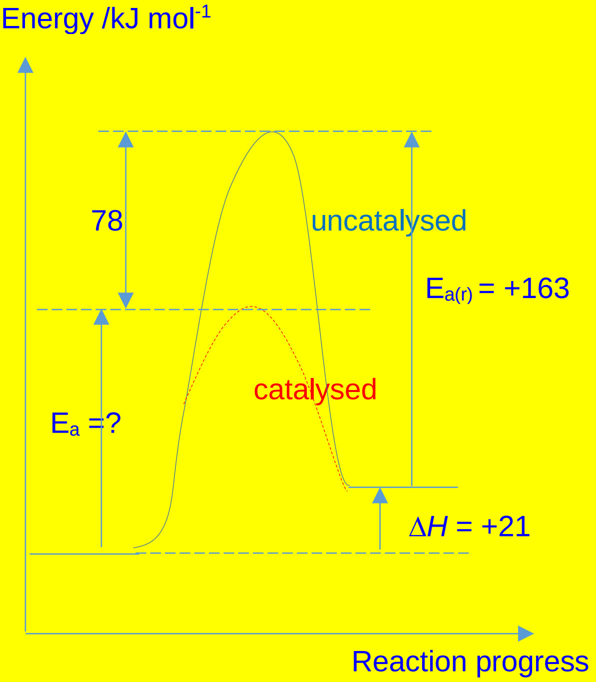
A 85 kJ mol^{-1}

B 106 kJ mol^{-1}

C 142 kJ mol^{-1}

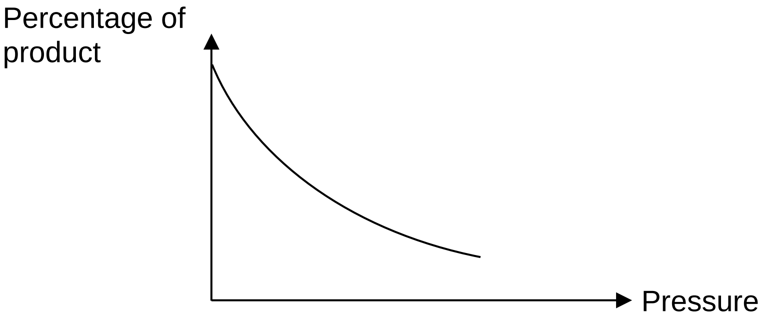
D 184 kJ mol^{-1}

Answer: **B**



Activation energy of the catalysed forward reaction,
$E_{a(f)} = 163 + 21 - 78 =$ **106 kJ mol^{-1}**

24 The graph below shows how the percentage of product present at equilibrium varies with pressure for a reaction at constant temperature.



Which reaction could the graph represent?

A $4Fe(s) + 3O_2(g) \rightleftharpoons 2Fe_2O_3(s)$

B $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

C $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

D $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(s)$

Answer: **C**

At constant temperature, when pressure increase, % of product decreases.
Eqm position shift to the left to reduce the pressure by reducing the no. of moles of particles.
Hence left side of the eqm should have less no. of moles of gaseous particles.

25 For which of the following reactions does K_c have the units $mol^{-1}\ dm^3$?

A $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

B $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

C $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

D $CH_3CO_2H(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CO_2CH_2CH_3(l) + H_2O(l)$

Answer: **A**

$$K_c = \frac{[SO_3]^2}{[O_2][SO_2]^2}$$

$$\text{unit of } K_c = \frac{(mol\ dm^{-3})^2}{(mol\ dm^{-3})(moldm^{-3})^2} = mol^{-1}\ dm^3$$

26 Which statement is correct to describe constitutional isomers?

A C_4H_{10} has 3 constitutional isomers.

B But-1-ene and pent-1-ene are examples of constitutional isomers.

C Constitutional isomers may differ in their chemical properties.

D Constitutional isomers may have different molecular formulae.

Answer: **C**

Constitutional (structural) isomers are compounds with the same molecular formula but different structural formulae.

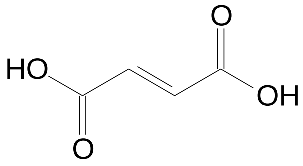
A is incorrect. C_4H_{10} has only two constitutional isomers.

B is incorrect. But–1–ene (C_4H_8) and pent–1–ene (C_5H_{10}) has different molecular formula.

C **is correct**. Functional group isomerism is a type of constitutional isomerism. Hence, the chemical properties of constitutional isomers may be different with different functional groups (e.g. esters and carboxylic acids)

D is incorrect. Constitutional isomers must have same molecular formula.

27 The skeletal formula of fumaric acid is shown.



fumaric acid

What is the empirical formula of fumaric acid?

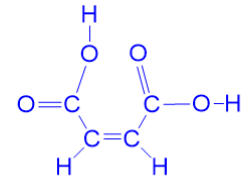
A CHO

B CH_2O_2

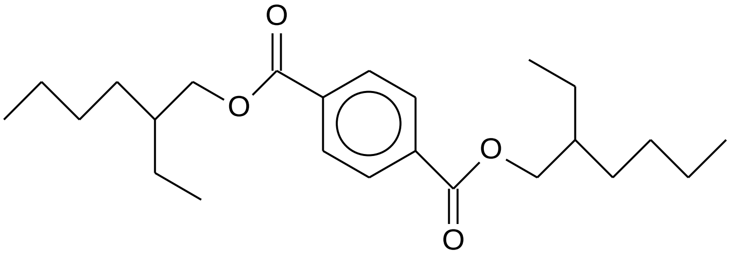
C C_2HO_2

D $C_4H_4O_4$

Answer: **A**

Displayed formula:	Molecular formula:	Empirical formula:
	$C_4H_4O_4$	CHO

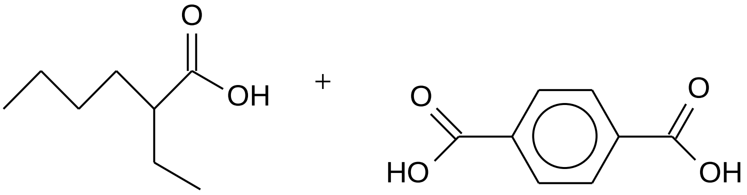
28 DOTP is used as a plasticiser to increase the fluidity of plastics such as PVC.



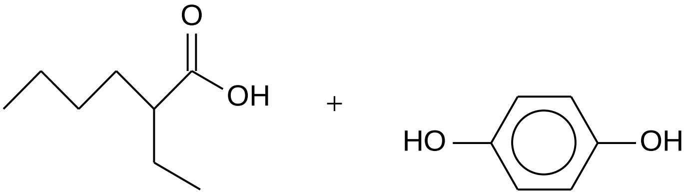
DOTP

Which reaction will produce DOTP under suitable conditions?

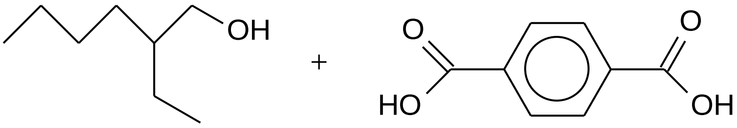
A



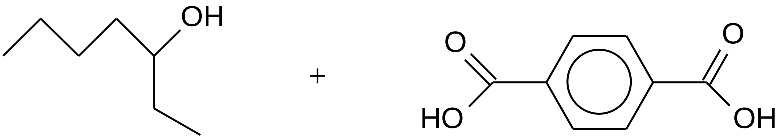
B



C

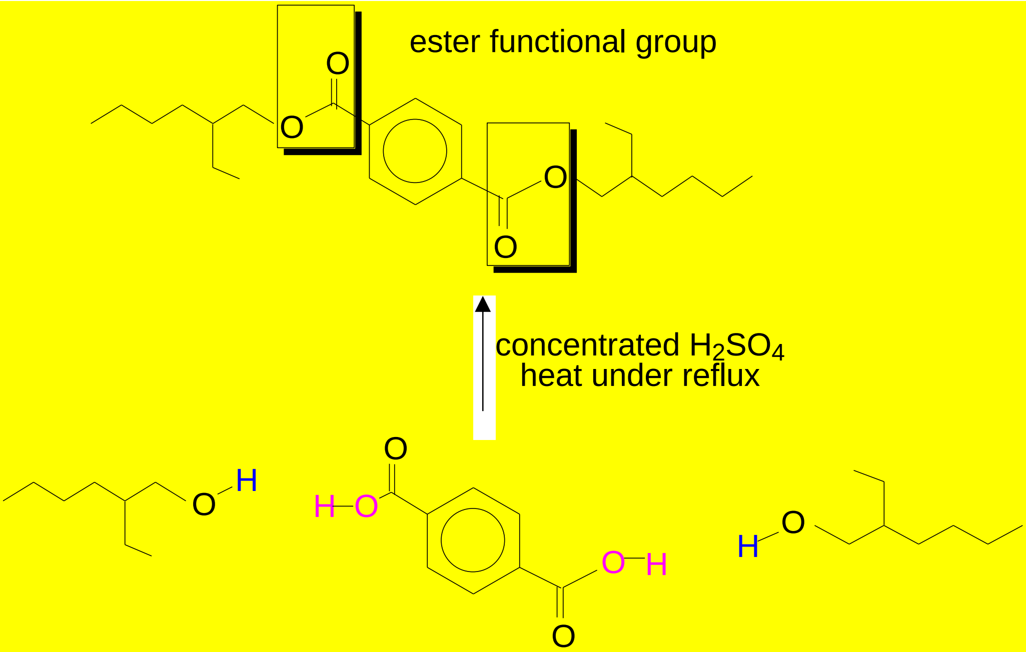


D



Answer: **C**

DOTP can be formed from the following reactants (alcohol and carboxylic acid) in the presence of concentrated H_2SO_4 and heat.



29 The compound $CH_3CH_2CH_2CONH_2$ is an amide.

Which statements about this amide are correct?

1 When heated with NaOH(aq), it will form sodium propanoate.

2 When heated with H_2SO_4(aq), it will form butanoic acid.

3 It can be formed using butanoic acid and NH_3(aq) at room temperature.

A 1 and 2 only **B** 1 and 3 only **C** 2 only **D** 3 only

Answer: **C**

1 is incorrect. Hydrolysis of the amide using NaOH(aq) will form NH_3(g) and a sodium carboxylate salt, containing 4 C atoms, not 3.

2 **is correct**. Butanoic acid is the product. NH_4^+ salt is also formed.

3 is incorrect. Butanoic acid and NH_3(aq) will react in an acid–base reaction at room temperature to form a salt $CH_3CH_2CH_2CO_2^-NH_4^+$, not an amide.

To form an amide, need to add DCC.

30 Polymers are used extensively in our daily lives.

Which row best describes the most suitable polymer to use for each type of product?

	soft contact lenses	raincoats	microwavable food packaging
A	poly(vinyl alcohol)	polyamide	LDPE
B	poly(vinyl alcohol)	poly(vinyl chloride)	poly(propene)
C	poly(vinyl chloride)	poly(vinyl alcohol)	LDPE
D	poly(vinyl chloride)	polyester	poly(propene)

Answer: **B**

Poly(vinyl alcohol) can have a higher water content as it can form hydrogen bonds with water molecules due to the presence of many –OH groups.

PVC is unable to form any hydrogen bonding with water. Polymer chains are closely packed together. Hence, water cannot seep into or seep through the PVC material.

Polypropene is inert and no functional groups such as ester or amide that will undergo hydrolysis with acid or base in food. Poly(propene) also has high melting point.