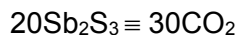
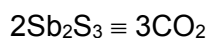
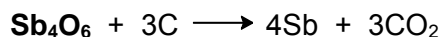


C



Volume of CO_2 produced at r.t.p. = $30 \times 24 = \underline{720 \text{ dm}^3}$

2 Angle of deflection, $\theta \propto \frac{\text{ionic charge}}{\text{mass}}$ (i.e. z/m ratio)

B

Arranging the species in order of **decreasing** angle of deflection, θ :

species	$^1\text{H}^+$	$^4\text{He}^{2+}$	$^9\text{Be}^{2+}$	$^{14}\text{N}^{3+}$	$^{12}\text{C}^{2+}$	$^{16}\text{O}^{2+}$	$^{27}\text{Al}^{3+}$	$^{12}\text{C}^+$
z/m	1.00	0.500	0.222	0.214	0.167	0.125	0.111	0.0833
identity			F	F	F		G	G

3

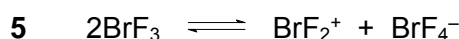
	no. of neutrons	no. of protons	ratio
^{10}B	5	5	1:1
^{32}P	17	15	
^{32}S	16	16	1:1
^{40}Ar	22	18	

B

4 Using $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

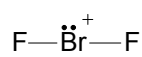
A

$$\begin{aligned}
 p_2 &= \frac{p_1 V_1 T_2}{V_2 T_1} \\
 &= \frac{1 \times 10^5 \times V_1 \times 373}{(3V_1 + V_1) \times 293} \\
 &= \frac{1 \times 10^5 \times 1 \times 373}{4 \times 293} \\
 &= \underline{3.18 \times 10^4 \text{ Pa}}
 \end{aligned}$$



D

Since the electrical conductivity of BrF_3 decreases (i.e. the position of equilibrium shifts left) when temperature increases, the **reverse endothermic** process is favoured to absorb the extra heat. Hence, the **forward** autoionisation process is **exothermic**.



Since there are 2 bond pairs and 2 lone pairs around the central Br atom, BrF_2^+ has a **bent** (non-linear) shape.

- 6 Total heat released = $(\frac{100}{65} \times 100 \times 4.18 \times 50) = 32.2 \text{ kJ}$ B
 Total heat released per gram = $\frac{1}{10} (32.154) = \underline{3.22 \text{ kJ g}^{-1}}$

- 7 Since $\Delta n_{\text{gas}} = +1 \text{ mol}$; $\Delta S > 0$. D
 Since $\Delta G < 0$ only at high temperatures, $\Delta H > 0$.
 (Since reaction involves breaking of C–O bond during thermal decomposition, $\Delta H > 0$.)

- 8 At the positive electrode (anode): C

species	E^\ominus
$\text{Cl}_2/\underline{\text{Cl}^-}$	+1.36
$\text{Cu}^{2+}/\underline{\text{Cu}}$	+0.34
$\text{Ni}^{2+}/\underline{\text{Ni}}$	–0.25

Since $E^\ominus(\text{Ni}^{2+}/\text{Ni})$ is the least positive, **Ni will be oxidised to Ni^{2+} .**

At the negative electrode (cathode):

species	E^\ominus
$\underline{\text{H}^+}/\text{H}_2$	0.00

H^+ will be reduced to H_2 .

- 9 Comparing expt. 1 and 2, B
 When volume of H_2O_2 is halved, time taken is doubled (i.e. rate is halved).
 \Rightarrow **first order w.r.t. H_2O_2**

Comparing expt. 2 and 4,
 When volume of I^- increased 1.5 times, time taken decreased 1.5 times (i.e. rate increased 1.5 times).
 \Rightarrow **first order w.r.t. I^-**

Comparing expt. 3 and 4,
 When volume of H_2O_2 is halved and volume of H^+ is doubled, time taken is doubled (i.e. rate is halved).
 Since reaction is first order w.r.t. H_2O_2 , increasing $[\text{H}^+]$ has no effect on the time taken.
 \Rightarrow **zero order w.r.t. H^+**

Rate equation: **rate = $k [\text{H}_2\text{O}_2] [\text{I}^-]$**

\Rightarrow one molecule of H_2O_2 and one I^- ion are involved in the slow step (r.d.s) of the mechanism

- 10 $\text{Mn}^{2+} + 2\text{e}^- \longrightarrow \text{Mn}$ C

$$n(\text{Mn}) = 1.3 / 54.9 = 0.0237 \text{ mol}$$

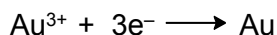
$$n(\text{e}^-) = 2 \times 0.0237 = 0.0474 \text{ mol}$$

$$\text{Using } Q = n_e F$$

$$Q = 0.0474 \times 96500 = 4574.1 \text{ C}$$

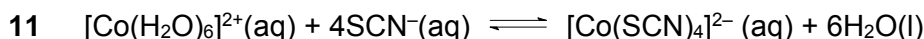
$$\text{Using } Q = It, I = Q/t$$

$$I = 4574.1 / (30 \times 60) = \underline{2.5 \text{ A}}$$



$$n(\text{Au}) = n(\text{e}^{-}) / 3 = 0.0474 / 3 = 0.0158 \text{ mol}$$

$$\text{mass of Au} = 0.0158 \times 197 = \underline{3.1 \text{ g}}$$



D

$$K_c = \frac{[\text{Co}(\text{SCN})_4]^{2-}]}{[\text{Co}(\text{H}_2\text{O})_6]^{2+}][\text{SCN}^{-}]^4}$$

$$\text{Units of } K_c = \frac{\text{mol dm}^{-3}}{\text{mol dm}^{-3} \times (\text{mol dm}^{-3})^4}$$

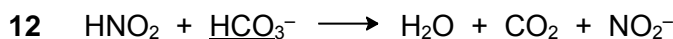
$$\text{Units of } K_c = \underline{\text{mol}^{-4} \text{ dm}^{12}} \quad \text{Hence, statement A is correct.}$$

$$10^3 = \frac{10}{1 \times [\text{SCN}^{-}]^4}$$

$$[\text{SCN}^{-}] = \underline{3.16 \times 10^{-1} \text{ mol dm}^{-3}} \quad \text{Hence, statement B is correct.}$$

Since K_c is more than 1, the position of equilibrium **lies to the right**. This indicates that $[\text{Co}(\text{SCN})_4]^{2-}$ is a more stable complex ion than $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$. Hence, statement **C** is correct.

Dilution of the reaction mixture decreases the concentration of ions in the solution. Hence, the **position of equilibrium shifts to the left** to increase the concentration of ions. This **increases** the proportion of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$. Hence, statement **D** is incorrect.



C

HCO_3^{-} acts as a *Bronsted base* which **accepts a proton** from HNO_2 , a *Bronsted acid*. The H_2CO_3 formed is unstable and decomposes to H_2O and CO_2 .

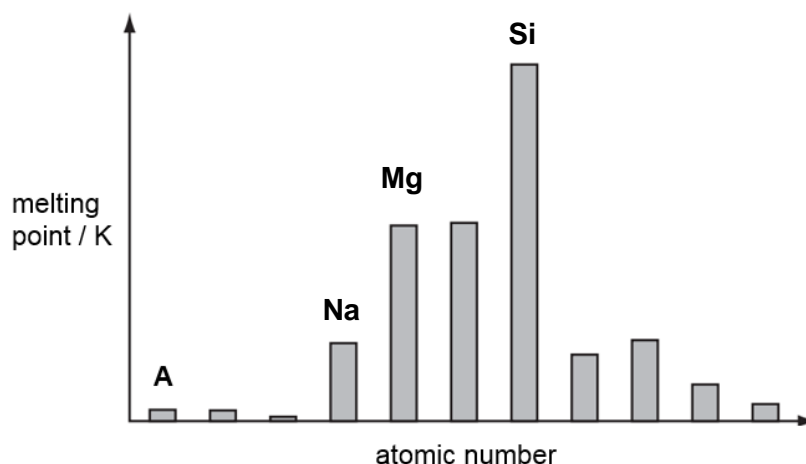
13 The working pH range of an indicator is between $\text{p}K_a - 1.00$ and $\text{p}K_a + 1.00$.

B

A suitable indicator will be one where the working pH range of the indicator lies within the range of rapid pH change at the end-point of the titration.

Hence, only the indicator in **B** fulfils the condition.

14



B

15	oxide	nature of oxide	reacts with dil. NaOH	remarks	D
	Al_2O_3	amphoteric	yes	–	
	P_4O_{10}	acidic	yes	–	
	SO_2	acidic	yes	–	
	SiO_2	acidic	no	only reacts with hot and concentrated strong alkalis to form silicates	

16 Each mineral behaves as a mixture of two carbonate compounds. D

mineral	formula	behaves as a mixture of
barytocalcite	$BaCa(CO_3)_2$	1 mol $BaCO_3$ and 1 mol $CaCO_3$
dolomite	$CaMg(CO_3)_2$	1 mol $CaCO_3$ and 1 mol $MgCO_3$
huntite	$Mg_3Ca(CO_3)_4$	3 mol $MgCO_3$ and 1 mol $CaCO_3$

The effectiveness of each of the three minerals as fire retardant is dependent on its **ease of thermal decomposition** to produce CO_2 , which smothers the fire.

The ease of thermal decomposition of the minerals is dependent on the charge density and hence the polarising power of the respective Group II metal ions (Ba^{2+} , Ca^{2+} and Mg^{2+}).

The order of effectiveness as fire retardant, from best to worst, corresponds to the order of decreasing polarising power of the Group II metal ions: Mg^{2+} , Ca^{2+} , Ba^{2+} .

Huntite is a more effective fire retardant than dolomite as huntite contains more $MgCO_3$ and hence it produces more CO_2 upon complete thermal decomposition.

17 I_2 undergoes a redox reaction with $S_2O_3^{2-}$, forming I^- and $S_4O_6^{2-}$. (Recall from 'Group VII') D

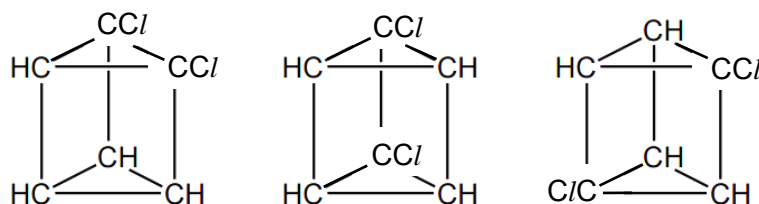
In the presence of excess KI, I_2 forms the complex ion I_3^- . Hence, the overall equation is as shown:



18 Since At is below I in Group VII, D

- Similar to AgI, AgAt is likely to be **insoluble** in excess dilute aqueous NH_3
- At_2 is a weaker oxidising agent than Cl_2 and hence, At_2 is **unable** to oxidise Cl^- to form At^- and Cl_2
- KAt and **concentrated** sulfuric acid react to form **At_2** (HAt formed initially is oxidised by the sulfuric acid)

19 The compound $C_6H_4Cl_2$ has the following **three** structural isomers: A



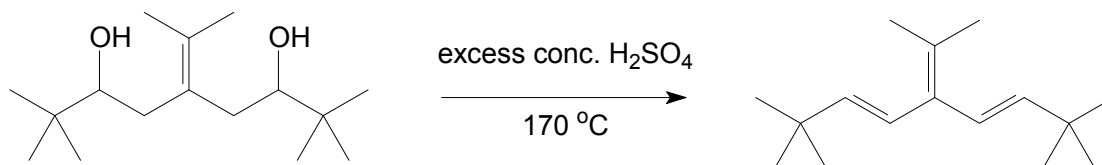
20

bond	bond energy / kJ mol ⁻¹
C–F	> 410
C–H	410
C–Cl	340

C

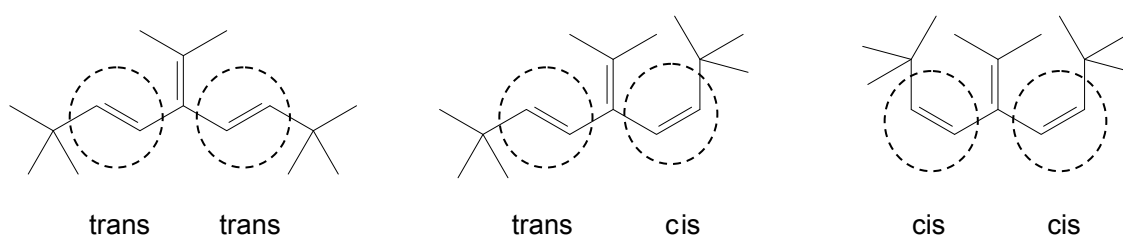
Irradiation of **CHFC/CF₂Cl** results in **homolytic fission** of the weakest C–Cl bond, forming the **•CHFCF₂Cl** radical.

21

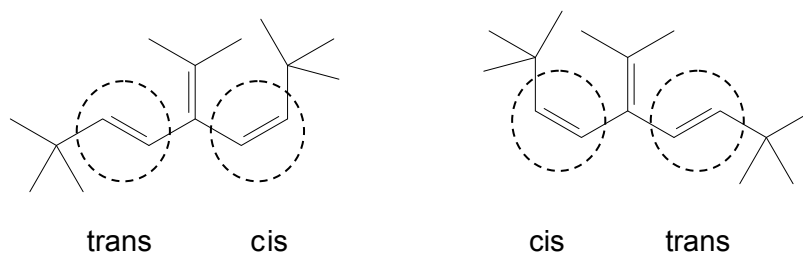


D

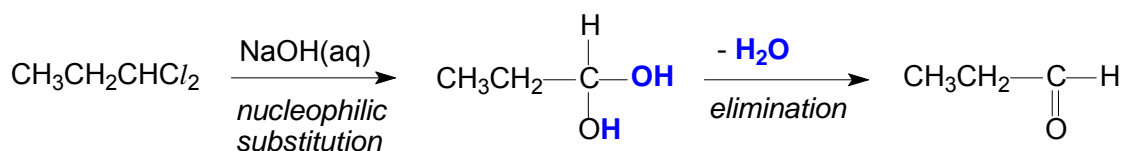
The **three** geometrical isomers of the product are as follows:



Note: The following two structures are equivalent.

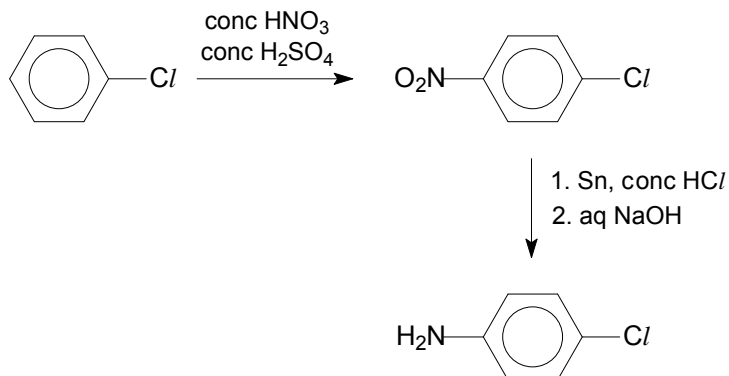


22



B

23



A

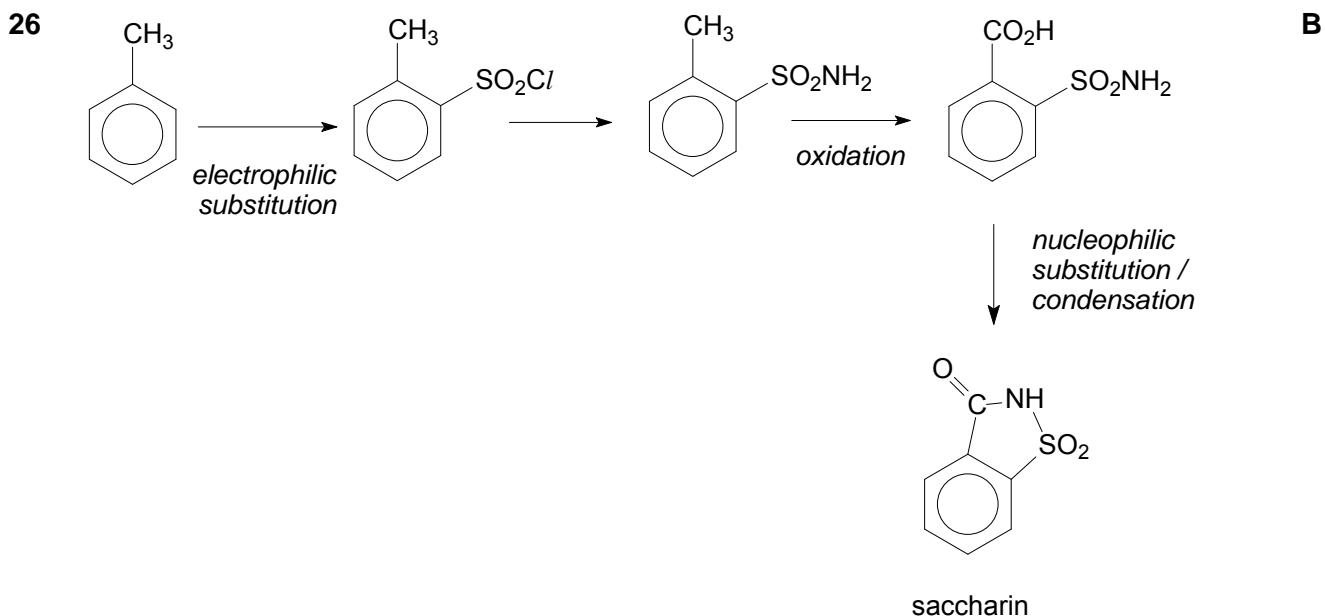
Note that –NO₂ is 3-directing and cannot be reduced using LiAlH₄.

- 24 The CN^- nucleophile attacks the **electron deficient** carbon in propanone in the **nucleophilic addition** mechanism. **B**
- 25 **Q hydrolyses** in water to produce a strongly acidic solution of $\text{CH}_3\text{CO}_2\text{H}$ and **HCl**. **B**
Hence, the resulting solution formed has the lowest pH.

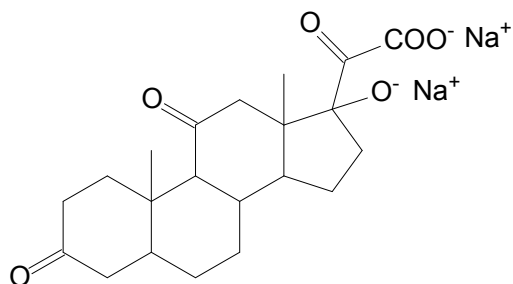
P, **R** and **S** are weak acids which ionise partially in water.

The presence of electronegative atoms (**Cl** and **Br**) on **R** and **S** exerts an electron-withdrawing effect on $\text{C}/\text{CH}_2\text{CH}_2\text{COO}^-$ and $\text{BrCH}_2\text{CH}_2\text{COO}^-$ respectively, which disperses the negative charge and stabilises the anion. Hence, the dissociation of $\text{CH}_3\text{CH}_2\text{COOH}$ to give H^+ ions is least favourable. The resulting solution from **P** has the highest pH.

Since **Cl** is more electronegative than **Br**, it exerts a stronger electron-withdrawing effect on $\text{C}/\text{CH}_2\text{CH}_2\text{COO}^-$ and hence $\text{C}/\text{CH}_2\text{CH}_2\text{COOH}$ is more acidic than $\text{BrCH}_2\text{CH}_2\text{CO}_2\text{H}$. Hence, the resulting solution from **R** has a lower pH than **S**.



- 27 **A:** aqueous KMnO_4 , dilute H_2SO_4 , heat **D**
For the compound on the left, purple solution decolourises.
(hydrolysis of ester + oxidation of primary alcohol)
For the compound on the right, purple solution remains.
- B:** aqueous KMnO_4 , dilute H_2SO_4 , heat
For the compound on the left, purple solution remains.
For the compound on the right, purple solution decolourises.
(side-chain oxidation on benzene ring)
- C:** aqueous Br_2 / neutral FeCl_3
For the compound on the left, orange solution remains / no violet colouration observed.
For the compound on the right, orange solution decolourises / violet colouration observed.



- 29 The four species given are conjugate acids of their corresponding amines.

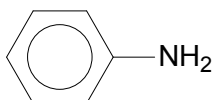
A

A low pK_a value for its conjugate acid will indicate a high pK_b value for the amine.

A decreasing pK_a value for the conjugate acids of the amines also indicates an increasing pK_b value for the amines.

Hence, the species can be arranged in the **order of decreasing basicity** of the corresponding amine.

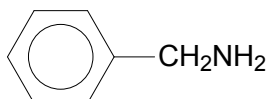
amine of I



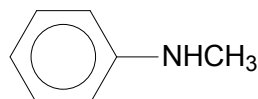
amine of II



amine of III



amine of IV



Amine of **III** is the most basic as the electron-donating alkyl group ($C_6H_5CH_2-$) increases the availability of lone pair on N.

Amines **I**, **II** and **IV** are less basic than that of **III** since the lone pair on N can be delocalised into the π electron cloud of the benzene ring, decreasing the availability of the lone pair.

Amine of **IV** is more basic than that of **I** and **II** as it is a secondary amine. The presence of the electron-donating alkyl group ($-CH_3$) increases the availability of the lone pair as compared to amines of **I** and **II**.

Amine of **II** is less basic than that of **I** as the presence of electron-withdrawing Cl decreasing the availability of the lone pair on N to a greater extent.

30 Possible combinations:

B

Glutamine Glutamic acid	$-\text{NH}_2$	$-\text{CO}_2\text{H}$
$-\text{NH}_2$	×	✓
$-\text{CO}_2\text{H}$ (1)	✓	×
$-\text{CO}_2\text{H}$ (2)	✓	×

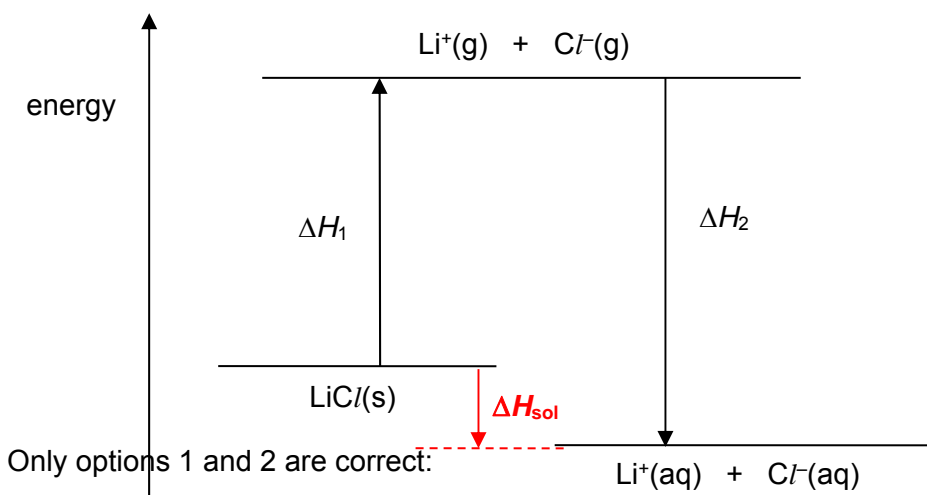
∴ 3 different compounds can be formed

31

	no. of protons	no. of electrons	no. of neutrons
OH^-	9	10	8
HCO_3^-	31	32	30
DCO_3^-	31	32	31

B

32



B

1. By Hess' law, $\Delta H_{\text{sol}}(\text{LiCl}) = \Delta H_1 + \Delta H_2$.
2. From the energy level diagram, $\text{LiCl(s)} \rightarrow \text{Li}^+(\text{aq}) + \text{Cl}^-(\text{aq})$ is an exothermic process. Hence, the process is accompanied by an increase in temperature.
3. Silver chloride is sparingly soluble while lithium chloride is soluble. Hence, $\Delta H_{\text{sol}}(\text{LiCl})$ is expected to be MORE exothermic than $\Delta H_{\text{sol}}(\text{AgCl})$.

33

1. When pressure is increased, the gaseous reactant particles become closer together. Hence, the frequency of effective collisions increases.
2. More molecules have energy greater than the E_a at a higher **temperature**.
3. Raising the pressure has no effect on the E_a . The E_a is lowered only in the presence of a catalyst.

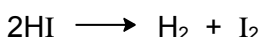
D

34

	electronic config.	no. of unpaired electrons
1. Cu^{2+}	$[\text{Ar}] 3d^9$	1
2. Mn^{3+}	$[\text{Ar}] 3d^4$	4
3. V^{3+}	$[\text{Ar}] 3d^2$	2

A

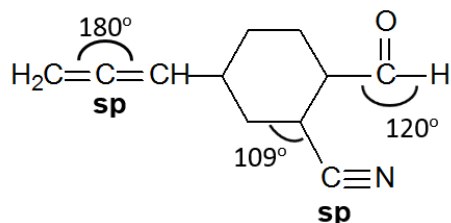
35



C

1. Gaseous hydrogen iodide appears as **white fumes** NOT brown
2. The hot rod provides the activation energy to break the H–I bond
3. The I_2 formed appears as purple fumes (violet black I_2 solids are also observed)

36



D

37 The reaction pathway diagram illustrates a **two-step** reaction mechanism.

D

1. Tertiary RX undergoes a two-step S_N1 mechanism
2. Primary RX undergoes a single step S_N2 mechanism
3. Same as option 2

38 The nucleophile (OH^- , CN^- , Br^-) can attack the carbocation / planar molecule from either side with equal probability in the S_N1 / nucleophilic addition / electrophilic addition mechanism.

C

A racemic mixture will not be formed in (1) since the product is not even chiral.

39 Compound 1 will undergo oxidative cleavage and compound 2 will undergo hydrolysis when reacted with hot acidified KMnO_4 .

B

Compounds with the structure $\text{CH}_3-\overset{\text{H}}{\underset{\text{OH}}{\text{C}}}-$ or $\text{CH}_3-\overset{\text{O}}{\underset{\text{O}}{\text{C}}}-$ will form a yellow ppt with alkaline aqueous iodine.

40 Option 1: Fe^{2+} in haemoglobin forms a stronger dative covalent bond with carbon monoxide than oxygen.
 Option 2: Each haemoglobin molecule contains 4 haem groups. One molecule of oxygen binds to the Fe^{2+} on each haem group.
 Option 3: The polypeptide chains in haemoglobin are held together by R group interactions.

B