**NATIONAL JUNIOR COLLEGE**
**SH2 PRELIMINARY EXAMINATION**
Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

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# CHEMISTRY

Paper 1 Multiple Choice

**9729/01**
**15 September 2021**
**1 hour**

Additional Materials: Optical Answer Sheet
Data Booklet

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**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.
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.

**Instructions on how to fill in the Optical Mark Sheet**
Shade the index number in a 5 digit format on the optical mark sheet:
1st digit and the last 4 digits of the Registration Number.

*Example:*

| Student | Examples of Registration No. | Shade: |
|---|---|---|
| | **2005648** | **25648** |

This document consists of **12** printed pages.

**Answer keys for 2021 SH2 H2 Chemistry Prelim Paper 1**

| | | | | | |
|---|---|---|---|---|---|
| **1** | **C** | **11** | **A** | **21** | **B** |
| **2** | **A** | **12** | **A** | **22** | **C** |
| **3** | **C** | **13** | **A** | **23** | **D** |
| **4** | **C** | **14** | **A** | **24** | **D** |
| **5** | **A** | **15** | **C** | **25** | **C** |
| **6** | **D** | **16** | **C** | **26** | **B** |
| **7** | **C** | **17** | **D** | **27** | **D** |
| **8** | **D** | **18** | **C** | **28** | **A** |
| **9** | **C** | **19** | **C** | **29** | **B** |
| **10** | **C** | **20** | **C** | **30** | **B** |

**1** A sample of element sulfur contains four isotopes of the following composition.

| relative isotopic mass | relative abundance |
|---|---|
| 32 | 95.02 |
| 33 | 0.76 |
| 34 | 4.20 |
| 36 | 0.02 |

What is the relative atomic mass of sulfur in this sample?

**A** 32.07 **B** 32.08 **C** 32.09 **D** 32.10

**Ans : C**

$$A_r = \left(\frac{95.02}{100} \times 32\right) + \left(\frac{0.76}{100} \times 33\right) + \left(\frac{4.2}{100} \times 34\right) + \left(\frac{0.02}{100} \times 36\right)$$
$$= 32.0924 \approx 32.09$$

**2** When 15 $cm^3$ of a gaseous organic compound were completely burnt in an excess of oxygen, 30 $cm^3$ of carbon dioxide and 15 $cm^3$ of nitrogen were formed, all volumes being measured at the same temperature and pressure.

Which could be the formula of the organic compound?

**A** $C_2H_4N_2$ **B** $C_2H_7NO$ **C** $C_3H_7NO$ **D** $C_3H_6N_2$

**Ans : A**

According to the question, all the carbon atoms in the organic compound are converted into $CO_2$ when burnt completely in excess $O_2$, and the nitrogen atoms are converted into $N_2$.

Assuming that the formula of the organic compound is $C_xH_yN_z$, when one mole of $C_xH_yN_z$ undergoes combustion, x moles of $CO_2$ will be produced and z/2 moles of $N_2$ will be produced.

The volume ratio of organic compound : $CO_2$ : $N_2$ = 15 $cm^3$ : 30 $cm^3$ : 15 $cm^3$
Mol ratio = 1 : 2 : 1

Hence x = 2 and z = 2 which fits the molecular formula $C_2H_4N_2$.

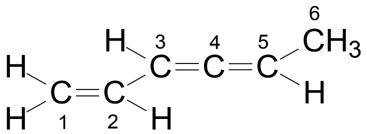
**3** Which ion has less electrons than neutrons and less neutrons than protons?

| | ion | neutrons | nucleons |
|---|---|---|---|
| **A** | $A^-$ | 18 | 37 |
| **B** | $B^{2+}$ | 17 | 34 |
| **C** | $C^{3+}$ | 16 | 33 |
| **D** | $D^{3-}$ | 16 | 31 |

**Ans : C**

| | **Identity** | **Neutrons** | **Protons** | **Electrons** |
|---|---|---|---|---|
| **A** | $A^-$ | 18 | 37 - 18 = 19 | 19 + 1 = 20 |
| **B** | $B^{2+}$ | 17 | 34 - 17 = 17 | 17 – 2 = 15 |
| **C** | $C^{3+}$ | 16 | 33 - 16 = 17 | 17 – 3 = 14 |
| **D** | $D^{3-}$ | 16 | 31 – 16 = 15 | 15 + 3 = 18 |

**4** Covalent bonds are formed by orbitals overlap.



Which statement does **not** describe the molecule above?

**A** The σ bond between C1–C2 is formed by $2sp^2$–$2sp^2$ overlap.

**B** The σ bond between C2–C3 is stronger than that between C5–C6.

**C** The π bond between C4–C5 is formed by $2sp$–$2sp^2$ overlap.

**D** The σ bond between C6–H is formed by $2sp^3$–1s overlap.

**Ans : C**

Option A is correct. The σ bond between C1–C2 is formed by $2sp^2$–$2sp^2$ overlap.

Option B is correct. The σ bond between C2–C3 is formed by $2sp^2$–$2sp^2$ overlap while that between C5–C6 is formed by $2sp^2$–$2sp^3$ overlap. $2sp^2$–$2sp^2$ overlap is more effective due to the hybridised orbitals having greater s character and results in a stronger bond.

Option C is wrong. The π bonds between C3–C4 and C4–C5 should be formed by side–on overlap of unhybridised 2p orbitals, **NOT** the hybridised orbitals.

Option D is correct. The σ bond between C6–H is formed by head on overlap of $2sp^3$ of C and 1s of H.

**5** Which options contain a polar and a non-polar molecule?

1 $CO_2$, $H_2O$

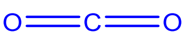
2 $SO_2$, $PCl_5$

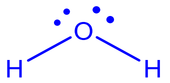
3 $CH_2Cl_2$ , $SiCl_4$

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

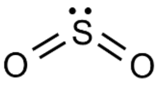
**Ans : A**

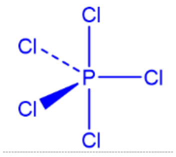
Option 1: $CO_2$ is non-polar while $H_2O$ is polar



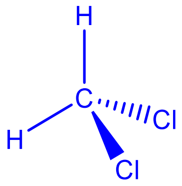


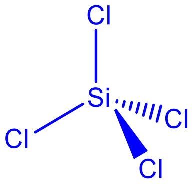
Option 2: $SO_2$ is polar while $PCl_5$ is non-polar



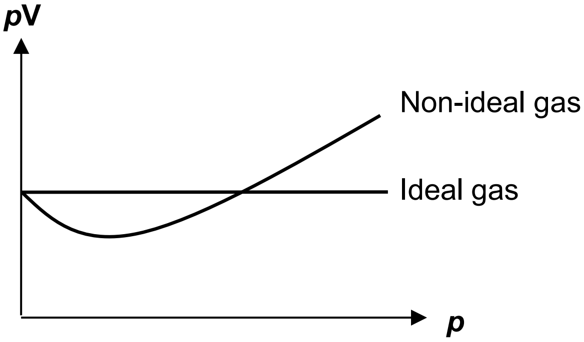


Option 3: $CH_2Cl_2$ is polar while $SiCl_4$ is non-polar





**6** The value of $pV$ is plotted against $p$ for two gases, an ideal gas and a non-ideal gas, where $p$ is the pressure and V is the volume of the gas.



Which gas shows the greatest deviation from ideal gas behaviour at 200 °C?

**A** $CO_2$ **B** $Cl_2$ **C** $CH_3OH$ **D** $N_2H_4$

**Ans : D**

Deviation from ideal gas behaviour is greatest for molecules with strongest intermolecular forces of attraction.
Both $CO_2$ and $Cl_2$ are non-polar molecules with weaker instantaneous dipole-induced dipole interactions (id-id) as compared to $CH_3OH$ and $N_2H_4$, which have stronger intermolecular hydrogen bonding. $N_2H_4$ has more extensive hydrogen bonds (an average of 2 H-bonds per molecule) than $CH_3OH$ (an average of 1 H-bond per molecule), hence $N_2H_4$ exhibit greatest deviation from ideal gas behaviour.

**7** Astatine is an element in Group 17. Which statements are correct?

1 Silver astatide is insoluble in aqueous ammonia.

2 Hydrogen astatide is less stable to heat than hydrogen iodide.

3 Astatine is more electronegative than iodine.

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

**Ans : C**

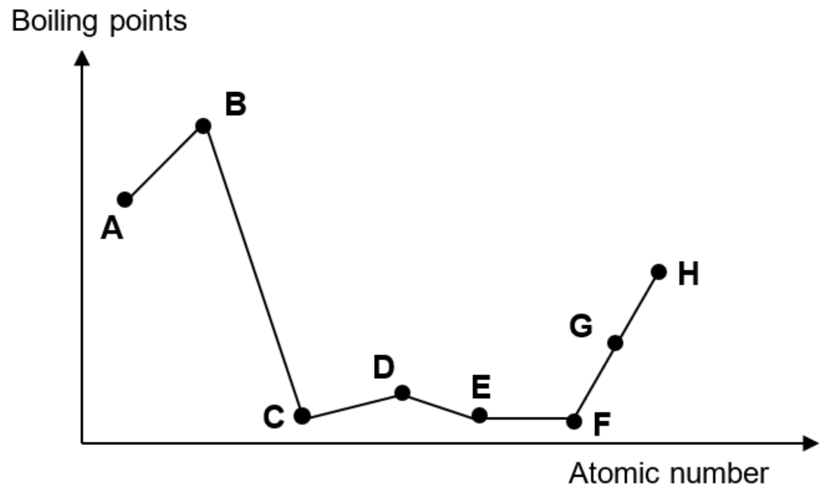
Astatine is below iodine in Group 17.

Option 1 is correct, solubility of AgX ppt in $NH_3$ decreases down the group.

Option 2 is correct, thermal stability decreases down the group due to weaker H−X bond.

Option 3 is wrong, Electronegativity decreases down the group.

**8** The graph below shows the variation in the boiling point for 8 consecutive elements in the Periodic Table, all with atomic number ≤ 20.



What can be deduced from the graph?

**A** The ions of **A** and **E** are isoelectronic.

**B** The chlorides become less acidic from **A** to **C**.

**C** When the oxide of **D** is added to water, the resulting solution has a pH greater than 7

**D** The oxide of **A** reacts with excess aqueous sodium hydroxide to form a soluble complex.

**Ans : D**

Drastic drop in boiling point from B to C => change in structure from giant covalent to simple covalent. B is Silicon, C is Phosphorus.

Option A is wrong. A is Aluminium (Group 13). Ions of A ($Al^{3+}$) and E($Cl^{-}$) are not isoelectronic ($Cl^{-}$ have 8 more electrons than $Al^{3+}$)

Option B is wrong. Chloride of A ($AlCl_3$) is acidic (pH = 3) due to significant hydrolysis to give $H^+$ ions, chlorides of B ($SiCl_4$) and C ($PCl_5$) are more acidic as they produce strong acid $HCl$ in water.

Option C is wrong. Oxide of D is $SO_3$. $SO_3 + H_2O \longrightarrow H_2SO_4$ which is acidic (pH < 7).

Option D is correct. Oxide of A ($Al_2O_3$) is amphoteric and can react with both acids & bases. It reacts with excess aq NaOH to form soluble complex $Na[Al(OH)_4]$.

**9** Given the following data:

| | |
|---|---|
| Lattice energy of magnesium chloride | $-2526$ kJ mol$^{-1}$ |
| Standard enthalpy change of hydration of chloride | $-384$ kJ mol$^{-1}$ |
| Standard enthalpy change of hydration of magnesium | $-1890$ kJ mol$^{-1}$ |

What would be the change in temperature measured when 0.49 g of magnesium chloride was dissolved in 50 g of water?
[Molar mass of $MgCl_2$ = 95.3 g mol$^{-1}$]

**A** − 6.2 °C **B** − 3.3 °C **C** + 3.3 °C **D** + 6.2 °C

**Ans : C**

$\Delta H_{sol} = \Delta H_{hyd}(Mg^{2+}) + 2\Delta H_{hyd}(Cl^{-}) - LE(MgCl_2) +$
$= (-1890) + 2(-384) - (-2526)$
$= -132$ kJ mol$^{-1}$

Amt of $MgCl_2$ in 0.49 g = 0.49/95.3 = $5.142 \times 10^{-3}$ mol
Heat gained by water, q = heat evolved = $132 \times 5.142 \times 10^{-3}$ = 0.6787 kJ = 678.7 J

$q = mc\Delta T$
$\Delta T = \frac{q}{mc} = \frac{(678.7)}{(50 \times 4.18)}$ = +3.25 °C (exothermic reaction, ΔT is positive)

**10** Combustion of carbon monoxide to form carbon dioxide is an exothermic reaction.

What can be deduced from this information?

1 $CO_2$ is more stable than CO.

2 The standard enthalpy change of formation of carbon dioxide is more exothermic than the standard enthalpy change of formation of carbon monoxide.

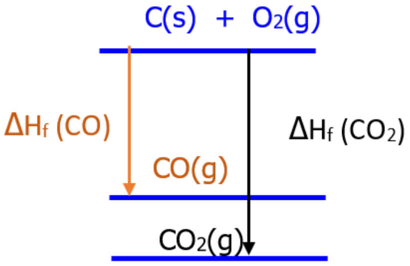
3 Combustion of CO has a low activation energy.

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

**Ans : C**

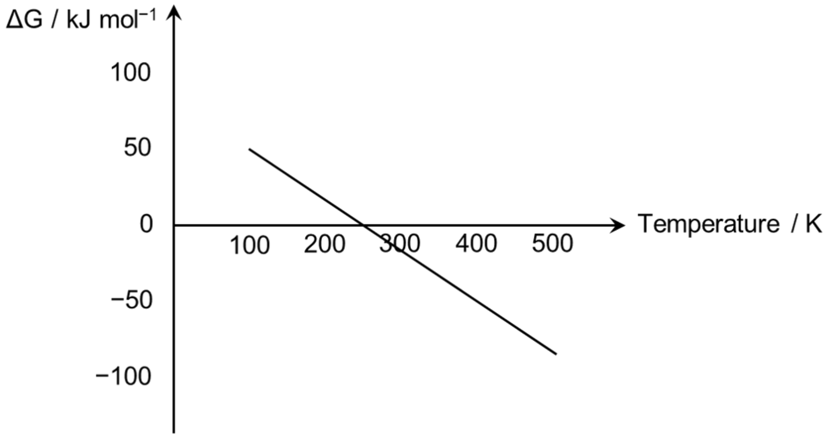
Option 1 is correct, since combustion is an exothermic process, energy level of $CO_2$ is lower than that of CO, hence $CO_2$ is more stable than CO.

Option 2 is correct, formation of $CO_2(g)$ from $C(s) + O_2(g)$ is an exothermic reaction (combustion). Since $CO_2$ has a lower energy level than CO, $\Delta H_f$ $CO_2(g)$ will be more exothermic than $\Delta H_f$ $CO(g)$.



Option 3 cannot be deduced as $\Delta H_c$ does not predict rate of reaction.

**11** What can be concluded about the values of $\Delta H$ and $\Delta S$ from this graph?

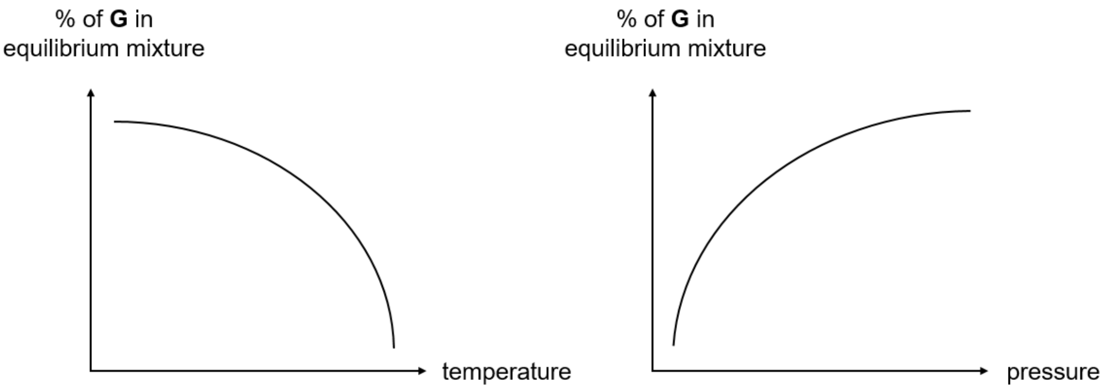


| | $\Delta H$ | $\Delta S$ |
|---|---|---|
| **A** | positive | positive |
| **B** | positive | negative |
| **C** | negative | positive |
| **D** | negative | negative |

**Ans : A**

$\Delta G = \Delta H - T\Delta S$
$Y = mX + c$
y-intercept (c) is $\Delta H$, gradient (m) is $-\Delta S$
From the graph when T = 0 K, $\Delta G$ is positive. This indicates that $\Delta H$ is positive as $T\Delta S = 0$.
Gradient is a negative value, hence $\Delta S$ is position.
OR
$\Delta G$ becomes more negative as temperature increases indicates that $\Delta S$ is a positive value as with a larger T, $T\Delta S$ became more larger resulting in $\Delta G$ to become more negative.

**12** Compound **G** is formed during a reaction involving only gaseous particles.
The graphs below show how the percentage of compound **G** at equilibrium varies with temperature and pressure.



Which equation represents the formation of compound **G**?

| | **equation** | $\Delta H$ |
|---|---|---|
| **A** | **E**(g) + 3**F**(g) $\rightleftharpoons$ 2**G**(g) | negative |
| **B** | 2**E**(g) $\rightleftharpoons$ **F**(g) + 2**G**(g) | positive |
| **C** | 4**D**(g) + 3**E**(g) $\rightleftharpoons$ 2**F**(g) + 6**G**(g) | negative |
| **D** | **E**(g) + **F**(g) $\rightleftharpoons$ 2**G**(g) | positive |

**Ans : A**

From the graphs, % of product **G** decreases with increasing temperature and % of product **G** increases with increasing pressure.
The increase in temperature causes position of equilibrium to shift left, favouring the endothermic reaction, hence forward reaction is exothermic.
The increase in pressure causes position of equilibrium to shift right, favouring the production of lesser moles of gas, hence forward reaction produces lesser mol of gas.

**13** Which reactions show $NH_3$ behaving as a Lewis base?

1 $HNO_3 + NH_3 \longrightarrow NH_4NO_3$

2 $2NH_3 \longrightarrow NH_2^- + NH_4^+$

3 $BH_3 + NH_3 \longrightarrow BH_3NH_3$

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

**Ans : A**

Lewis base is an electron pair donor.

Option 1 is correct, $NH_3$ donates electron pair to accept $H^+$ from $HNO_3$.

Option 2 is correct, $NH_3$ donates electron pair to accept $H^+$ from the other $NH_3$.

Option 3 is correct, $NH_3$ donates electron pair to $BH_3$ via dative bond.

**14** The auto-ionisation of $H_2O$ is an endothermic process.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \qquad K_w = 1.0 \times 10^{-14} \text{ at } 25\ °C$$

Which option is correct about water at 60 °C?

**A** $pH < 7$ **B** $pH = 7$ **C** $[H^+] > [OH^-]$ **D** $[H^+] < [OH^-]$

**Ans : A**

The auto-ionisation of water is endothermic, at a higher temperature of 60 °C, the position of equilibrium favours the forward direction, hence $K_w > 1.0 \times 10^{-14}$.
Since $pK_w = pH + pOH$ and $pH = pOH$ for neutrality, a larger $K_w$ leads to a smaller $pK_w$ which will result in pH and pOH BOTH taking a value below 7.

Options **C** and **D** are common misconceptions. The position of equilibrium is different at a different temperature, but the new $[H^+]$ and the new $[OH^-]$ remain equal.

**15** A 1 $dm^3$ solution contains $2 \times 10^{-4}$ mol $dm^{-3}$ each of magnesium, strontium, iron(II) and silver(I) ions.

Which carbonate will be precipitated first when 1 mol $dm^{-3}$ sodium carbonate is added dropwise into the solution?

| | compound | $K_{sp}$ |
|---|---|---|
| **A** | Magnesium carbonate | $1.3 \times 10^{-7}$ $mol^2\ dm^{-6}$ |
| **B** | Strontium carbonate | $9.3 \times 10^{-10}$ $mol^2\ dm^{-6}$ |
| **C** | Iron(II) carbonate | $2.1 \times 10^{-11}$ $mol^2\ dm^{-6}$ |
| **D** | Silver(I) carbonate | $8.1 \times 10^{-12}$ $mol^3\ dm^{-9}$ |

**Ans : C**

$K_{sp}$ ($MgCO_3$) = $[Mg^{2+}][CO_3^{2-}]$
$1.3 \times 10^{-7} = (2 \times 10^{-4})\ [CO_3^{2-}]$
$[CO_3^{2-}] = \frac{1.3 \times 10^{-7}}{2 \times 10^{-4}} = 6.5 \times 10^{-4}$ mol $dm^{-3}$

$K_{sp}$ ($SrCO_3$)= $[Sr^{2+}][CO_3^{2-}]$
$9.3 \times 10^{-10} = (2 \times 10^{-4})\ [CO_3^{2-}]$
$[CO_3^{2-}] = \frac{9.3 \times 10^{-10}}{2 \times 10^{-4}} = 4.65 \times 10^{-6}$ mol $dm^{-3}$

$K_{sp}$ ($FeCO_3$)= $[Fe^{2+}][CO_3^{2-}]$
$2.1 \times 10^{-11} = (2 \times 10^{-4})\ [CO_3^{2-}]$
$[CO_3^{2-}] = \frac{2.1 \times 10^{-11}}{2 \times 10^{-4}} = 1.05 \times 10^{-7}$ mol $dm^{-3}$ (lowest conc of $CO_3^{2-}$ required, ppt first)

$K_{sp}$ ($Ag_2(CO_3)$)= $[Ag^+]^2\ [CO_3^{2-}]$
$8.1 \times 10^{-12} = (2 \times 10^{-4})^2\ [CO_3^{2-}]$
$[CO_3^{2-}] = \frac{8.1 \times 10^{-12}}{(2 \times 10^{-4})^2} = 2.03 \times 10^{-4}$ mol $dm^{-3}$

**16** Ethyl ethanoate undergoes an acid-catalysed hydrolysis in water where the concentration of acid in the solution remains constant.

$$CH_3CO_2CH_2CH_3 + H_2O \xrightarrow{H^+} CH_3CO_2H + CH_3CH_2OH$$

The rate equation is found to be rate = k[$CH_3CO_2CH_2CH_3$][$H^+$]

In an experiment, when 0.01 mol dm$^{-3}$ HC*l* was reacted with 0.10 mol dm$^{-3}$ ethyl ethanoate, the half-life was found to be 42 min.

In a second experiment, 0.02 mol dm$^{-3}$ HC*l* was reacted with 0.40 mol dm$^{-3}$ ethyl ethanoate.

What is the half-life of the second experiment?

**A** 6.25 min **B** 10.5 min **C** 21 min **D** 42 min

**Ans : C**

Since HC*l* is the catalyst and is regenerated at the end of the reaction, concentration of HC*l* remains constant during the reaction, this is a pseudo-first order reaction.

rate = k'[$CH_3CO_2CH_2CH_3$] where k' = k[$H^+$]

For 1st order reaction, half-life, $t_{1/2} = \frac{ln\,2}{k'}$

In this reaction, $t_{1/2} = \frac{ln\,2}{k\,[H^+]}$

when [HC*l*] = 0.01 mol dm$^{-3}$, half-life = 42 min,

when [HC*l*] = 0.02 mol dm$^{-3}$, half-life = 21 min.

**17** What is the rate equation for the reaction with the mechanism shown?

$$\begin{array}{rcll} 2A & \rightleftharpoons & A_2 & \text{fast} \\ A_2 + B & \longrightarrow & A_2B & \text{slow} \\ A_2B + B & \longrightarrow & A_2B_2 & \text{fast} \end{array}$$

**A** Rate = k[A]$^2$

**B** Rate = k[A][B]

**C** Rate = k[$A_2$][B]

**D** Rate = k[A]$^2$[B]

**Ans : D**

fast equilibrium step 1 $K_c = \frac{[A_2]}{[A]^2}$

$[A_2] = K_c\,[A]^2$

From slow step, rate $= k\,[A_2]\,[B]$

$= k\,(K_c\,[A]^2)\,[B]$

$= k'\,[A]^2[B]$

Note : intermediate cannot appear in the rate equation.

**18** Which species is the weakest oxidising agent under standard conditions?

**A** $Ag^+$ (aq) **B** $Cu^{2+}$ (aq) **C** $Fe^{2+}$ (aq) **D** $H^+$ (aq)

**Ans : C**

Weakest oxidising agent is one that is least likely to be reduced. It would have the least positive $E^\ominus$ value.

| | | |
|---|---|---|
| $Ag^+ + e^-$ | $\rightleftharpoons$ $Ag$ | +0.80 |
| $Cu^{2+} + e^-$ | $\rightleftharpoons$ $Cu^+$ | +0.15 |
| $Cu^{2+} + 2e^-$ | $\rightleftharpoons$ $Cu$ | +0.34 |
| $Fe^{2+} + 2e^-$ | $\rightleftharpoons$ $Fe$ | –0.44 |
| $2H^+ + 2e^-$ | $\rightleftharpoons$ $H_2$ | 0.00 |

**19** Each gold medal awarded in the Olympic Games weighs 500 g. The gold plating constitutes 1.2% by mass of the gold medal.

The core of the medal is immersed in a solution of gold(III) chloride and connected to a power source with a current of 0.10 A.

What is the time required to electroplate the desired mass of gold?

**A** $1.76 \times 10^4$ s **B** $2.94 \times 10^4$ s **C** $8.81 \times 10^4$ s **D** $7.35 \times 10^6$ s

**Ans : C**

[R] $Au^{3+} + 3e^- \longrightarrow Au$

Amt of Au = $\frac{6.0}{197.0}$ = 0.03046 mol

Amt of $e^-$ = 3 × 0.03046 = 0.09137 mol

$Q = I \times t = n_e \times F$

$(0.10) \times t = 0.09137 \times 96500$

t = 88173 s

**20** It has been estimated that for every atom of chlorine or bromine generated from a halogenoalkane in the stratosphere, one hundred thousand molecules of ozone may be destroyed.

Which organic compound would cause the most destruction to ozone?

**A** $CF_2C\mathit{l}CH_2CF_2C\mathit{l}$

**B** $CC\mathit{l}_2BrCH_2Br$

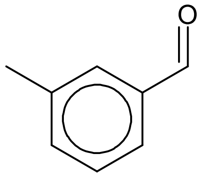
**C** $CHC\mathit{l}_2CBr_3$

**D** $CC\mathit{l}_4$

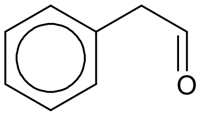
**Ans : C**

Option C contains the greatest number of chlorine and bromine atom.

**21** Compounds **X** and **Y** are isomers with the molecular formula $C_8H_8O$.



Compound **X**



Compound **Y**

Which reagent can be used to distinguish between **X** and **Y**?

**A** Hot acidified $K_2Cr_2O_7$

**B** Hot acidified $KMnO_4$

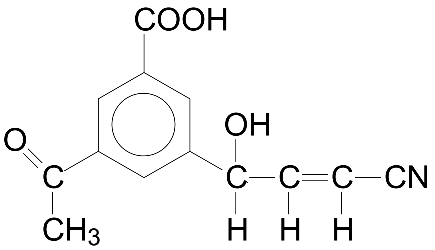
**C** $[Ag(NH_3)_2]^+$, heat

**D** $I_2$, NaOH(aq), warm

**Ans : B**

| | Compound **X** | Compound **Y** |
|---|---|---|
| Hot acidified $K_2Cr_2O_7$ (oxidation of all aldehyde) | Orange $K_2Cr_2O_7$ turns green | Orange $K_2Cr_2O_7$ turns green |
| Hot acidified $KMnO_4$ (oxidation of alkyl side chain of benzene and aldehyde) | Purple $KMnO_4$ decolourises.<br>No effervescence. | Purple $KMnO_4$ decolourises with effervescence of $CO_2$ that gives white ppt with $Ca(OH)_2$ |
| $[Ag(NH_3)_2]^+$, heat (Tollens' reagent, oxidation of all aldehyde) | Silver mirror formed | Silver mirror formed |
| $I_2$, NaOH(aq), warm | No yellow ppt | No yellow ppt |

**22** How many moles of $H_2$ will react with 1 mole of the following compound in the presence of platinum catalyst?



**A** 2 **B** 3 **C** 4 **D** 5

**Ans : C**

1 mol of $H_2$ to react with ketone
1 mol of $H_2$ to react with C=C
2 mol of $H_2$ to react with C≡N
$H_2$(g) with Pt is not able to reduce benzene and −COOH

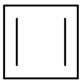
**23** In 1931, the German chemist Erich Hückel formulated a theory to help determine if a species would be considered aromatic. This rule became known as Hückel's rule.

The compound must meet all the following four criteria to be considered as aromatic:

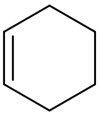
- a cyclic structure (a ring of atoms)
- a planar ring structure (all atoms in the ring must lie in the same plane)
- a fully conjugated ring structure (continuous lateral overlap of p orbitals at every atom in the ring)
- a ring structure has (4n+2) $\pi$ electrons (n = 0 or any positive integer)

Which molecules are aromatic?

1



2



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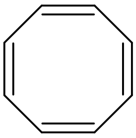


**A** 1 only

**B** 2 and 3 only

**C** 1 and 3 only

**D** None of the above

**Ans : D**

Option 1 is not aromatic. Each of the four atoms in the ring contain an unhybridised p orbital (C=C). It has total of 4$\pi$ electrons (4$\pi$ electrons from 2 C=C pi bonds), not 4n+2.

Option 2 is not aromatic. The four $sp^3$ hybridised C atoms is tetrahedral in geometry, hence it does not have a planar ring structure.

Option 3 is not aromatic. Each of the eight atoms in the ring contain an unhybridised p orbital (C=C). It has total of 8$\pi$ electrons (8$\pi$ electrons from 4 C=C pi bonds), not 4n+2.

**24** Which molecule **cannot** be used to synthesise propanoic acid in less than 3 steps?

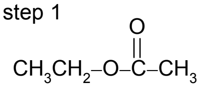
**A** $CH_3CH_2COCH_3$

**B** $CH_3CH_2CONH_2$

**C** $CH_3CH_2CH_2CH_2Br$

**D** $CH_3CH_2OCOCH_3$

**Ans : D**

| Option A | Option B |
|---|---|
| step 1<br>$CH_3CH_2COCH_3 \xrightarrow{I_2 \text{ / NaOH, warm}} CH_3CH_2COO^-$<br>step 2<br>$CH_3CH_2COO^- \xrightarrow{HCl\text{ (aq)}} CH_3CH_2COOH$ | $CH_3CH_2CONH_2 \xrightarrow[\text{heat under reflux}]{HCl\text{(aq)}} CH_3CH_2COOH$ |
| **Option C** | **Option D** |
| step 1<br>$CH_3CH_2CH_2CH_2Br \xrightarrow[\text{heat under reflux}]{\text{ethanolic NaOH}} CH_3CH_2CH{=}CH_2$<br>step 2<br>$CH_3CH_2CH{=}CH_2 \xrightarrow[\text{heat under reflux}]{KMnO_4 \text{ in } H_2SO_4\text{(aq)}} CH_3CH_2COOH$ | step 1<br> $CH_3CH_2{-}O{-}\overset{\overset{O}{\Vert}}{C}{-}CH_3 \xrightarrow[\text{heat under reflux}]{HCl\text{ (aq)}} CH_3CH_2OH$<br>step 2<br>$CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl$<br>step 3<br>$CH_3CH_2Cl \xrightarrow[\text{heat under reflux}]{\text{ethanolic NaCN}} CH_3CH_2CN$<br>step 4<br>$CH_3CH_2CN \xrightarrow[\text{heat under reflux}]{HCl\text{ (aq)}} CH_3CH_2COOH$ |

**25** During the preparation of many organic compounds, by-products are formed. This usually occurs because the reagents can react in more than one way depending on the conditions used or because the products formed may react with the reactants.

Propanol is produced by the reaction between bromopropane and aqueous sodium hydroxide.

$$CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$$

What could be a by-product of this reaction?

1 $CH_3CH{=}CH_2$

2 $CH_3CH(OH)CH_3$

3 $CH_3CH_2CH_2ONa$

**A** 1, 2 and 3

**B** 1 and 3 only

**C** 1 only

**D** None of the above

**Ans : C**

Option 1 is correct. The product $CH_3CH_2CH_2OH$ provides an alcoholic medium for elimination of H and Br from $CH_3CH_2CH_2Br$ to occur:
$CH_3CH_2CH_2Br + NaOH(alc) \longrightarrow CH_3CH{=}CH_2 + NaBr + H_2O$

Option 2 is wrong. $CH_3CH(OH)CH_3$ would require reaction of $CH_3CH{=}CH_2$ with $H_2O$ in presence of concentrated acid.

Option 3 is wrong. $CH_3CH_2CH_2OH$ is neutral and would not react with NaOH

**26** The hydride ion, $H^-$, is a strong reducing agent, a good nucleophile and a good base.

Which conversion **cannot** be carried out by the hydride ion?

**A** $C_3H_7Br$ to $C_3H_8$

**B** $CH_2=CH_2$ to $CH_3CH_3$

**C** $C_6H_5OH$ to $C_6H_5O^-$

**D** $CH_3CN$ to $CH_3CH_2NH_2$

Ans : B

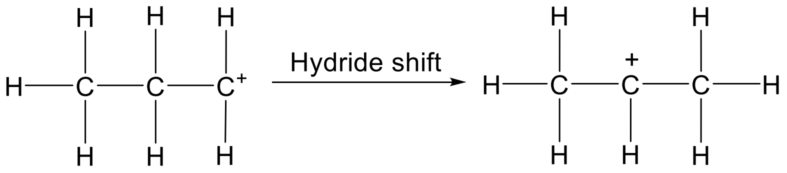
**Option A:** $C_3H_7Br$ to $C_3H_8$. $H^-$, being a good nucleophile, undergoes nucleophilic substitution with $C_3H_7Br$ to form $C_3H_8$.

**Option B:** $CH_2=CH_2$ to $CH_3CH_3$. $H^-$, being negatively charged, **does not react** with electron rich C=C bond in $CH_2=CH_2$.

**Option C:** $C_6H_5OH$ to $C_6H_5O^-$. $H^-$, being a good base, undergoes acid base reaction with acidic phenol, $C_6H_5OH$ to form $C_6H_5O^- + H_2$.

**Option D:** $CH_3CN$ to $CH_3CH_2NH_2$. $H^-$, being a strong reducing agent, reacts with the d+ C in C≡N of $CH_3CN$ and reduces it to form $CH_3CH_2NH_2$.

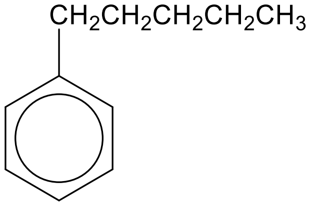
**27** Hydride shift is a rearrangement process which produces a more stable carbocation. For example, after removing the halogen from $CH_3CH_2CH_2Cl$, a hydride shift will take place as shown.



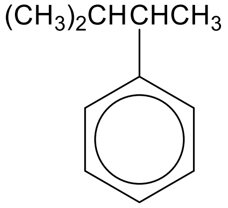
In another experiment, $(CH_3)_2CHCHClCH_3$ reacts with benzene in the presence of $FeCl_3$.

Which product would most likely be formed?

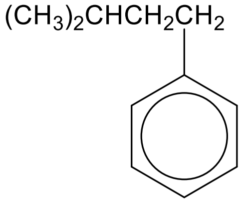
**A**



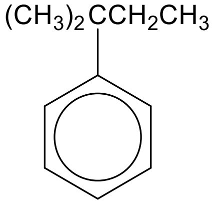
**B**



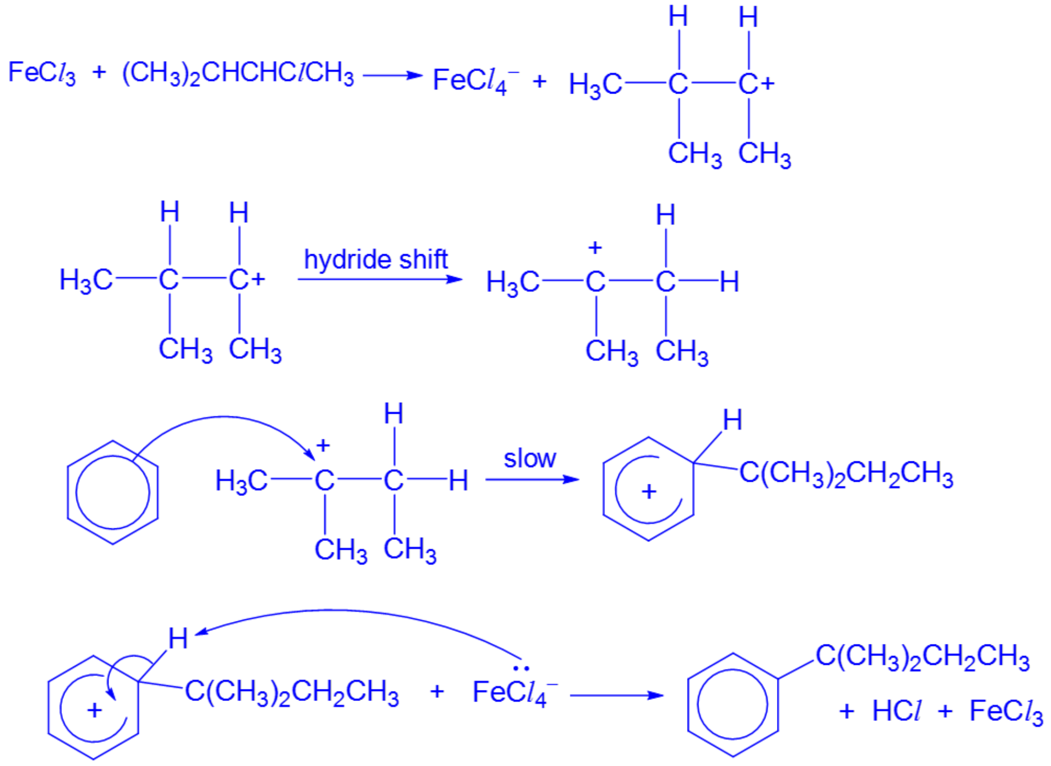
**C**



**D**



**Ans : D**



**28** Which reaction yields a carbon compound incorporating deuterium, D? [D = $^{2}_{1}H$]

**A** $CH_3CHO \xrightarrow[\text{dry ether}]{\text{LiA/D}_4}$

**B** $CH_3CH_2CN \xrightarrow[D_2O]{\text{NaOD}}$

**C** $(CH_3)_3COH \xrightarrow[\text{heat}]{\text{conc. } D_2SO_4}$

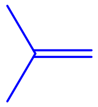
**D** $CH_3CD(OD)CH_3 \xrightarrow[\text{heat}]{\text{acidified } KMnO_4}$

**Ans : A**

A) Reduction $CH_3CHO \xrightarrow[\text{dry ether}]{\text{LiA/D}_4}$ $\mathbf{CH_3CH(D)OH}$

B) Alkaline Hydrolysis $CH_3CH_2CN \xrightarrow[D_2O]{\text{NaOD}} CH_3CH_2COO^{-}Na^{+}$

C) Elimination $(CH_3)_3COH \xrightarrow[\text{heat}]{\text{conc. } D_2SO_4}$



$+ H_2O$

D) Oxidation $CH_3CD(OD)CH_3 \xrightarrow[\text{heat}]{\text{acidified } KMnO_4} CH_3COCH_3$

**29** What is the predominant form of glycine, $NH_2CH_2COOH$, in a solution of pH 3?
(Given $pK_{a1} = 2.3$ and $pK_{a2} = 9.6$).

**A** $^{+}NH_3CH_2CO_2H$

**B** $^{+}NH_3CH_2CO_2^{-}$

**C** $NH_2CH_2CO_2H$

**D** $NH_2CH_2CO_2^{-}$

**Ans: B**

$pK_a$ is for the −COOH and $-NH_3^{+}$ groups in the protonated glycine.

−COOH (lower $pK_a$, 2.3) is more acidic than $-NH_3^{+}$ (higher $pK_a$, 9.6).

When pH = $pK_a$, ratio of –COOH (weak acid)= $-COO^{-}$(conjugate base) is 1:1.

Since solution of pH 3 is higher than the $pK_a$ of the –COOH (2.3), this indicates that predominant form is $-COO^{-}$.

Since solution of pH 3 is lower than the $pK_a$ of $-NH_3^{+}$. The predominant form is $-NH_3^{+}$.

The main form of glycine in a solution of pH 3 is $^{+}NH_3CH_2CO_2^{-}$

**30** Transition metals like platinum and rhodium are found in catalytic converters fitted into cars. Which statement best explains the role of transition metals in this use?

**A** Transition metals can exhibit variable oxidation states in their compounds as 3d and 4s electrons have similar energies.

**B** Transition metals have available and partially filled 3d orbitals for the adsorption of reactant molecules.

**C** Transition metals have very high melting points because both 3d and 4s electrons are involved in forming strong metallic bonds.

**D** Transition metals form coloured ions due to absorption of energy in the visible light region to promote an electron from a lower to a higher energy 3d orbitals.

**Ans : B**

Transition Element concepts