NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/01**
Paper 1 Multiple Choice **19 September 2024**
1 hour

Additional Materials: Optical Answer Sheet
Data Booklet

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:
2nd digit and the last 4 digits of the Registration Number.

Example:

Student	Examples of Registration No.	Shade:
	2305648	**35648**

This document consists of **15** printed pages and **1** blank page.

Suggestion solution for P1 (MCQ)

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

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

A sample of 35.6 g of hydrated sodium carbonate contains 25.84% sodium ions by mass. When this sample is heated, anhydrous sodium carbonate and water vapour are formed.

What is the mass lost?

A	7.2 g	**B**	10.6 g	**C**	14.4 g	**D**	21.2 g

Ans: C

$Na_2CO_3.xH_2O \rightarrow Na_2CO_3 + xH_2O$

$\frac{46}{106 + 18(x)} \times 100\% = 25.84$

x = 4

Mass of water given off = $\frac{35.6}{178} \times 18 \times 4 = 14.4g$

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

Sodium and fluorine are both reactive elements.

Which statements are correct?

	1	One Na atom has two more protons than one F^- ion.
	2	One Na atom has two more neutrons than one F atom.
	3	One Na^+ ion has the same number of electrons as one F^- ion.

Ans: A

	F	→	F^-		Na	→	Na^+
p	9		9		11		11
n	10		10		12		12
e	9		10		11		10

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

3 When iodine is oxidized by nitric acid, a white crystalline solid oxide can be isolated from the mixture.

0.001 mole of this oxide reacts with 0.01 mole of acidified potassium iodide to give 0.006 mole of iodine, I_2.

What is the oxidation number of iodine in the oxide?

A	+1	**B**	+5	**C**	+6	**D**	+10

Ans: B

0.001 mol of iodine oxide reacts with 0.01 mol of I^- to gives 0.006 mol of I_2.
Balancing number of I atoms on both sides,
0.006 mol of I_2 contains 0.012 mol of I atoms.
Hence, 0.001 mol of iodine oxide contains 0.002 mol of iodine atoms.

0.002 mol I^{x+} reacts with 0.010 mol I^- to produce 0.006 mol I_2.

[O] $2I^- \longrightarrow I_2 + 2e^-$
0.010 mol I^- gives 0.010 mol of e^-

[R] $I^{x+} + ne^- \longrightarrow I_2$
0.002 mol of I^{x+} gains 0.010 mol of e^-
1 mol of I^{x+} gains 5 mol of e^- to give I_2

During **reduction**, oxidation state of I^{x+} **decreases** by **5** units from **+5** to **0**.

4 Which pair of compounds meets the criteria below?

- The first compound has a larger bond angle than the second compound.
- The second compound is more polar than the first compound.

A	CO_2, BCl_3	**B**	IF_3, H_2O	**C**	HCN, SO_3	**D**	CO_2, NCl_3

Ans: D

molecules	bp	lp	shape	angle	Polar?
CO_2	2	0	Linear	180°	Non polar
BCl_3	3	0	Trigonal planar	120°	Non polar
IF_3	3	2	T-shape	~90°	Polar
H_2O	2	2	Bent	105°	Polar
HCN	2	0	Linear	180°	Polar
SO_3	3	0	Trigonal Planar	120°	Non polar
NCl_3	3	1	Trigonal pyramidal	107.5°	Polar

5 Hydrogen peroxide solution decomposes. The equation for this reaction is shown.

$$2H_2O_2\,(aq) \longrightarrow 2H_2O\,(l) + O_2(g)$$

A 300 cm^3 sample of hydrogen peroxide solution is warmed. After 150 minutes, 10.00 dm^3 of oxygen gas, measured at r.t.p., is collected. Under these conditions, the reaction has a constant half-life of 50 minutes.

	What is the initial concentration of the hydrogen peroxide solution?
	A 0.79 mol dm^{-3}
	B 1.6 mol dm^{-3}
	C 2.8 mol dm^{-3}
	D 3.2 mol dm^{-3}

Ans: D
For first order reaction, half-life is constant

Time	[Reactant]	[Product]
0	100%	0%
1st $t_{1/2}$	50%	50%
2nd $t_{1/2}$	25%	75%
3rd $t_{1/2}$	12.5%	87.5%

After 3 half−lifes (50 mins × 3), 10.00 dm^3 of O_2 = 87.5% of O_2 produced.

Maximum volume of O_2 = $10.00 \times \frac{100}{87.5}$ = 11.43 dm^3

Maximum amount of O_2 at r.t.p. = $\frac{11.43}{24}$ = 0.4762 mol

Initial amount of H_2O_2 = 0.4762 × 2 = 0.9524 mol

Initial conc of H_2O_2 = $\frac{0.9524}{0.3}$ = 3.17 mol dm^{-3}

6 In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid. The increase in temperature is 12°C.

In a second experiment, the same method is used, but 50.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid.

What is the increase in temperature in the second experiment?

A 6°C **B** 12°C **C** 24°C **D** 48°C

Ans: B

$H^+ + OH^- \rightarrow H_2O$
0.05 0.05 0.05
q = mcΔT
= (25+25) x 4.18 x 12
= 2508 J

$H^+ + OH^- \rightarrow H_2O$
0.1 0.1 0.1

	$q = mc\Delta T$ $2508 \times 2 = (50+250) \times 4.18 \times \Delta T$ $\Delta T = 12°C$

7	X and Y react together to form Z in a reversible reaction. The equilibrium yield of Z at different conditions are shown in the following table. **Conditions** / **Equilibrium yield of Z** High Temperature / Decreased High Pressure / Increased Which equation could represent this reaction?	
	A	$X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = -100$ kJ mol^{-1}
	B	$X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = +100$ kJ mol^{-1}
	C	$X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\Delta H = -100$ kJ mol^{-1}
	D	$X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\Delta H = +100$ kJ mol^{-1}
	Ans: A Higher temperature, equilibrium shifts left which favour endothermic reaction. Therefore, the forward reaction is an exothermic reaction. Lower pressure, equilibrium shifts left since L.H.S has greater number of moles of gases.	

8	PCl_5 decomposes as shown. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ 1.0 mole of $PCl_5(g)$, 1.0 mole of $PCl_3(g)$ and 1.0 mole of $Cl_2(g)$ are placed in a container of volume 2 dm^3 at 250 °C and allowed to reach equilibrium. At this temperature, the equilibrium mixture contains 1.8 moles of PCl_3. What is the value of K_c at 250 °C?							
	A	0.12	**B**	1.8	**C**	8.1	**D**	16.2
	Ans: C $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ I (mols) 1 1 1							

	C (mols) -0.8 +0.8 +0.8 E (mols) 0.2 1.8 1.8 $K_c = \frac{(0.9)(0.9)}{0.1} = 8.1$

9	Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product. How are the carbonate ions behaving during this reaction?	
	A	Brønsted-Lowry acid
	B	Brønsted-Lowry base
	C	oxidising agent
	D	reducing agent
	Ans: B $(NH_4)_2CO_3 \rightarrow 2NH_3 + H_2O + CO_2$ CO_3^{2-} gained H^+ to form H_2CO_3 which spontaneously forms $H_2O + CO_2$ on warming. Therefore it is a Brønsted-Lowry base.	

10	The dissociation constant, K_w, for the ionisation of water, $H_2O \rightleftharpoons H^+ + OH^-$, at different temperatures is given below. Temperature / °C: 0, 25, 50 K_w / mol² dm⁻⁶: 1.15×10^{-15}, 1.00×10^{-14}, 5.50×10^{-14} Which statement is correct?	
	A	Only at 25 °C are $[H^+]$ and $[OH^-]$ equal.
	B	The equilibrium lies furthest to the right at 0 °C.
	C	The forward reaction is exothermic.
	D	The pH of water decreases with temperature.

Ans: D

Option **A** is incorrect as the $[H^+]$ and $[OH^-]$ of water are equal at all temperatures.
Option **B** is incorrect as the value of K_w is the smallest (across the three temperatures) at 0 °C. Hence, equilibrium lies most to the left.
Option **C** is incorrect as K_w increases with temperature, the forward reaction is favoured.
Option **D** is correct as an increase in temperature favours the endothermic reaction, hence the forward reaction is endothermic.

Option **D**:
$K_w = [H^+]\,[OH^-]$
$K_w = [H^+]^2$
$pH = -\log \sqrt{(K_w)}$
as K_w increases with temperature, pH will decrease.

11 The indicator bromophenol blue, HIn, changes colour from yellow to blue over a pH range of 3.0 to 4.6.

Which statements are correct?

	1	When bromophenol blue is added to water at 25 °C, $[HIn] < [In^-]$.
	2	Bromophenol blue would be a suitable indicator for the titration of a strong base and a weak acid.
	3	The In^- ions are yellow.

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

Ans: C

Water has a pH of 7, so the indicator would show blue colour, which means

$[HIn] < [In^-]$.Hence statement 1 is correct.

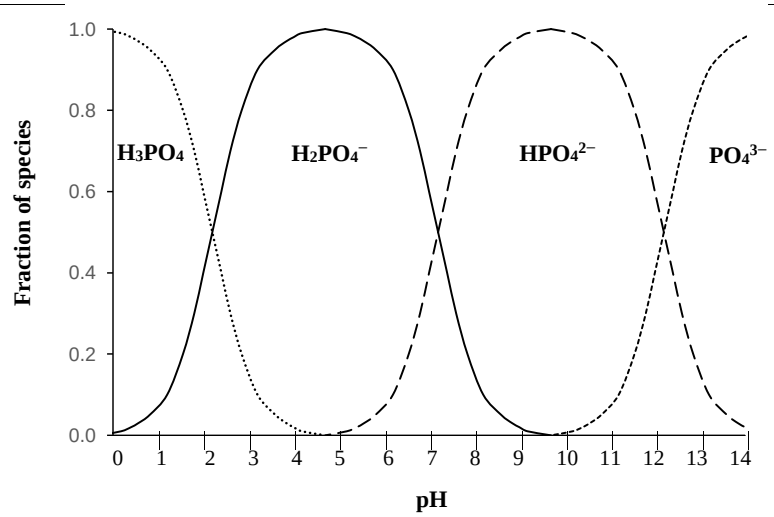
Statement 2 is incorrect: The end point of the titration between a strong base and weak acid > pH 7, which is beyond the working range of bromophenol blue.

Statement 3 is incorrect: Since bromophenol blue changes colour from yellow to blue over a pH range of 3.0 to 4.6, this implies that the colour of the solution will be yellow and blue for pH < 3.0 and pH > 4.6 respectively. (HIn molecule is yellow while In^- ion is blue.)

12 Phosphoric acid is a tribasic acid.

$$H_3PO_4 \overset{K_{a1}}{\rightleftharpoons} H_2PO_4^- + H^+$$
$$H_2PO_4^- \overset{K_{a2}}{\rightleftharpoons} HPO_4^{2-} + H^+$$
$$HPO_4^{2-} \overset{K_{a3}}{\rightleftharpoons} PO_4^{3-} + H^+$$

The graph shows the fraction of each species at different pH.



What is the numerical value of K_{a2}?

A	2.0×10^{-10}	**B**	7.9×10^{-8}	**C**	2.0×10^{-5}	**D**	6.3×10^{-3}

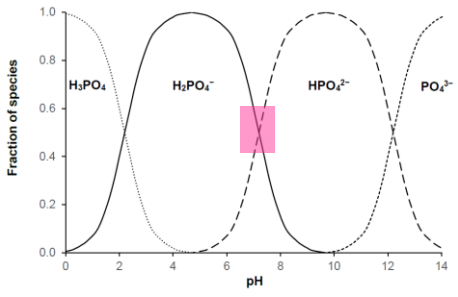
Ans: B

To determine K_{a2}, identify the acid ($H_2PO_4^-$) and the salt (HPO_4^{2-}) present & use the buffer equation.

$$pH = pK_{a2} + \lg \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$$

At Maximum Buffer Capacity, $[HPO_4^{2-}] = [H_2PO_4^-]$, $pH = pK_{a2}$.

Hence, we need to find the point in the graph where $[HPO_4^{2-}] = [H_2PO_4^-]$.



From graph, when $[HPO_4^{2-}] = [H_2PO_4^-]$, pH ~ 7.1 => pK_a= 7.1,

Hence $K_a = 10^{-7.1} = 7.94 \times 10^{-8}$

13	An acidified solution contains 0.10 mol dm^{-3} of $ZnSO_4$ and 0.10 mol dm^{-3} of $CuSO_4$. Hydrogen sulfide gas, H_2S, is bubbled through the solution until it is saturated with H_2S at 15 °C. The concentration of $S^{2-}(aq)$ in the solution reaches 1×10^{-35} mol dm^{-3}. The solubility product of ZnS at 15 °C is 1×10^{-24} mol^2 dm^{-6} and that of CuS is 1×10^{-40} mol^2 dm^{-6}. Which statement is correct?	
	A	No precipitate is formed.
	B	ZnS only is precipitated.
	C	CuS only is precipitated.
	D	Both ZnS and CuS are precipitated.
	Ans: C Ionic product of ZnS = $[Zn^{2+}]$ $[S^{2-}]$ = (0.10) (10^{-35}) = 10^{-36} mol^2 dm^{-6} ($<10^{-24}$) Ionic product of CuS = $[Cu^{2+}]$ $[S^{2-}]$ = (0.10) (10^{-35}) = 10^{-36} mol^2 dm^{-6} ($>10^{-40}$) Hence, only CuS gets precipitated.	

14	In this question the symbol '<' means 'less positive than' or 'more negative than'. Silver chloride dissolves in dilute $NH_3(aq)$ whereas silver bromide is only soluble in concentrated NH_3. The following equations represent the equilibria involved. $AgCl(s) \rightleftharpoons AgCl(aq)$ ΔG_1 $AgCl(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2Cl(aq)$ ΔG_2 $AgBr(s) \rightleftharpoons AgBr(aq)$ ΔG_3 $AgBr(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2Br(aq)$ ΔG_4 Some relationship between the free energies of these four reactions are as follows.	
	1	$(\Delta G_1 + \Delta G_2) < (\Delta G_3 + \Delta G_4)$
	2	$\Delta G_2 = \Delta G_4$
	3	$\Delta G_2 < \Delta G_4$
	4	$\Delta G_1 < \Delta G_3$

	Which relationships are correct?						
	A	**1, 2** and **4**	**B**	**1** and **3**	**C**	**2** and **4**	**D**	**3** only

14 **Ans: A**

AgCl is more soluble than AgBr, meaning ΔG_1 is more negative than ΔG_3.
Option 4 is true
$\Delta G_2 = \Delta G_4$ as formation of complex ion is due to the following equation and unaffected by the identity of the halide ions.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$$

Option 2 is true and option 3 is false.

Option 1 is true.

15 **X**, **Y** and **Z** are elements all found within Groups 13, 14 and 15 of the Periodic Table.

X is in the same group in the Periodic Table as **Y**.

Y and **Z** are in Period 3.

The first ionisation energy of **X** is greater than the first ionisation energy of **Y**.
The melting point of **Z** is less than the melting point of **Y**.

Which row shows the possible identities of **X** and **Y**?

	X	**Y**
A	B	Al
B	Ge	Si
C	As	P
D	N	P

15 **Ans: A**

X is in the same group in the Periodic Table as **Y**. The first ionisation energy of **X** is greater than the first ionisation energy of **Y**.
➔**X** must be in an earlier period than **Y**.
➔Option B & C wrong

Y and **Z** are in Period 3. The melting point of **Z** is less than the melting point of **Y**.
➔Melting point of Si > Al > P
➔ Y cannot be P
➔Option D is wrong

16	The solids sodium bromide and sodium iodide both react with concentrated sulfuric acid at room temperature. With NaBr, the products formed are S and Br_2. With NaI, the products formed are H_2S and I_2. Which statement can be deduced from the above information?	
	A	Iodine will displace the bromide ions from the solution.
	B	Sodium bromide is more volatile than sodium iodide.
	C	Iodide ions are stronger reducing agents than bromide ions.
	D	Sulfuric acid act as a dehydrating agent with NaI.

16	**Ans: C** A. **Wrong** – Iodine is a weaker oxidising agent than bromine. B. **Wrong** – Reaction did not show their boiling point. C. **True** - The 2 reaction shows how the halide reacted with H_2SO_4. I^- acted as a reducing with H_2SO_4 but not with Br^-. There is no change in oxidation state change for S when reacted with Br^- but when reacted with I^-, S in H_2SO_4 (+6) oxidation is being reduced to -2 in H_2S. D. D. **Wrong** - There is an oxidation state change for I^- to become I_2. So H_2SO_4 is an oxidizing agent

17	Equal amount of two Period 3 oxides were added to water. The resultant solution has a pH below 7. What are the identities of the two oxides?	
	A	Al_2O_3 and MgO
	B	Na_2O and MgO
	C	SiO_2 and Al_2O_3
	D	Na_2O and P_4O_{10}

17 **Ans: D**

A. Al_2O_3 (pH=7, insoluble in water) and MgO (pH > 7, ionic oxide➔ basic)
➔Overall = pH > 7

B. Na_2O (pH > 7, ionic oxide➔ basic) and MgO (pH > 7, ionic oxide➔ basic)
➔Overall = pH > 7

C. SiO_2 (pH=7, insoluble in water) and Al_2O_3 (pH=7, insoluble in water)
➔Overall = pH = 7

D. Na_2O (pH > 7, ionic oxide➔ basic) and P_4O_{10} (pH < 7, covalent oxide➔ acidic)

$Na_2O(s) + H_2O(l) \rightarrow 2\ NaOH(aq)$
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$

$3NaOH + H_3PO_4\ (aq) \rightarrow 4Na_3PO_4$

NaOH is the limiting reagent, hence excess H_3PO_4 is present, so the **pH Will be below 7**

18	Which statements are correct?							
	1	Magnesium carbonate decomposes at a lower temperature than calcium carbonate.						
	2	Calcium chloride has a higher boiling point than magnesium chloride.						
	3	Calcium is a stronger reducing agent than magnesium.						
	A	**1** and **2**	**B**	**1** and **3**	**C**	**2** and **3**	**D**	**3** only

18 **Ans: B**

1. **Correct statement.**
- The $\frac{\text{charge}}{\text{size}}$ **ratio of the $Mg^{2+}$is larger** leading to a larger polarising power.
- The **C–O bond** in the anion is being **polarised and weaken to a larger extent**
- **Less thermal energy is required to break the C–O bonds** in the carbonate anion.
- Therefore, **thermal stability of the $MgCO_3$ lower** thus the **decomposition temperature lower** for **$MgCO_3$**.

2. Wrong Statement

- Both $CaCl_2$ and $MgCl_2$ have giant ionic lattice structure with strong ionic bonds between the ions.
- Mg and Ca present in both species has a charge of +2. OH^- has a charge of –1.
- However, Ca^{2+} has larger ion size than Mg^{2+}

- Given $|L.E| \propto |\frac{q+ \times q-}{r+ + r-|,}|$
- Magnitude of lattice energy of $CaCl_2$ is **smaller** than that of $MgCl_2$.
- Thus, ionic bond strength in $CaCl_2$ is **weaker** than that in $MgCl_2$.
- Boiling point for $CaCl_2$ is lower.

3. Correct statement

- $Ca^{2+} + 2e^- \rightleftharpoons Ca$ $\quad E^\ominus = -2.87$
  $Mg^{2+} + 2e^- \rightleftharpoons Mg$ $\quad E^\ominus = -2.38$ V

- $E^\ominus$ (Ca^{2+}/Ca) more negative than $E^\ominus$ (Mg^{2+}/Mg).
- Ca is more likely to being oxidised to Ca^{2+}than Mg to be oxidised to Mg^{2+} (Ca reducing agent)
- Ca is a better/stronger reducing agent than Mg

19 A yellow solution is formed when concentrated hydrochloric acid is added to blue aqueous copper(II) chloride solution. Addition of potassium iodide to the mixture results in the formation of a brown solution and a white solid.

What type of reaction occurred in this sequence?

1	Redox reaction
2	Ligand exchange
3	Precipitation of copper(II) compound

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

19 **Ans: A**

Statement 3 - False , Statement 1 - True

Redox reaction occurred. Addition of potassium iodide to the mixture results in the formation of a brown solution **(I_2)** and a white precipitate **(CuI, copper (I) iodide – reduction of Cu^2 to Cu^+)**.

Statement 2 TRUE - Colour change in the solution from blue to yellow indicate a ligand exchange reaction has occurred.

Blue colour complex : $[Cu(H_2O)_6]^{2+}$ and yellow colour complex : $[CuCl_4]^{2-}$

20 Platinum(IV) chloride reacts with ammonia to form a compound in which the coordination number of platinum is 6. When dissolved in water, 1 mole of this compound gave 3 moles of ions.

What could be the formula of this compound?

	A	$Pt(NH_3)_6Cl_4$	**B**	$Pt(NH_3)_6Cl_2$
	C	$Pt(NH_3)_4Cl_4$	**D**	$Pt(NH_3)_4Cl_2$

Ans: C

NH_3 must always exist as the ligand in all complex, hence only chlorine can exist as either ligands or as Cl^- anion.

C. TRUE - $Pt(NH_3)_4Cl_4$ ➔ $[Pt(NH_3)_4Cl_2,]^{2+} + 2Cl^-$, ➔ 3 ions in total

A. WRONG - $[Pt(NH_3)_6]^{4+} + 4Cl$- ions, when dissociated with give 5 ions

B. WRONG - $Pt(NH_3)_6Cl_2$ ➔ For this to be a coordinate number 6 complex ion, it will have a formula $[Pt(NH_3)_6]^{2+} + 2Cl^-$,. Pt need to exist as a +2 state. But Pt will not undergo redox/ reduced from Pt^{4+} to Pt^{2+} due to absence of reducing agent.

D. WRONG - $Pt(NH_3)_4Cl_2$ ➔ For this to be a coordinate number 6 compound, it will have a formula $[Pt(NH_3)_4Cl_2]$. Pt need to exist as a +2 state. But Pt will not undergo redox/ reduced from Pt^{4+} to Pt^{2+}

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

Which statement is **not** true about the first-row transition metals and their compounds?

	A	$[Fe(CN)_6]^{3-}$ does not oxidise I^-.
	B	$Fe_2(CO_3)_3$ can be prepared by reacting $FeCl_3$(aq) with Na_2CO_3(aq).
	C	On addition of acidified $KMnO_4$(aq) to Fe^{2+}(aq), a yellow solution is formed.
	D	On addition of NH_3(aq) to $FeCl_2$ a green precipitate is formed which turns brown on standing.

21 **Ans: B**

A. TRUE

$Fe(CN)_6^{3-} + e^- \rightleftharpoons Fe(CN)_6^{4-}$ $E^\ominus = +0.36V$

$I_2 + 2e^- \rightleftharpoons 2I^-$ $E^\ominus = +0.56$ V

Ecell = +0.36 – (+0.56)
= –0.20V

Not feasible

B FALSE
Fe^{3+} polarises the water molecules, giving H^+ in the solution. The H^+ will react with the CO_3^2 to give CO_2 and $Fe(OH)_3$ will be formed instead.

C.TRUE

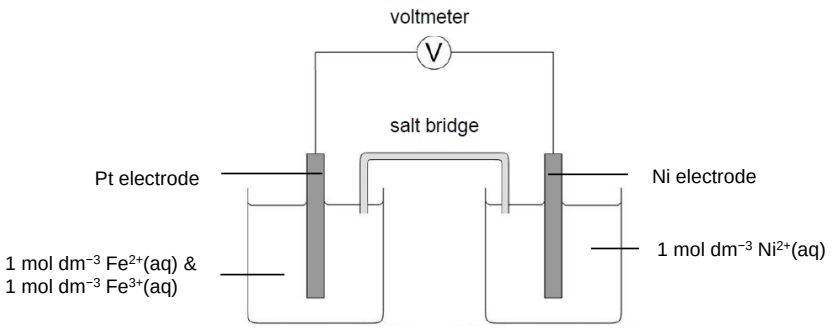
MnO_4^- + $8H^+$ + $5e^-$ ⇌ Mn^{3+} + $5H_2O$ $E^\ominus$ = +1.52V
Fe^{3+} + e^- ⇌ Fe^{2+} $E^\ominus$ = +0.77 V
Ecell = +1.52 – (+0.77)
= +0.65V
Reaction is feasible. Colourless Mn^{2+} and yellow Fe^{3+} formed.

4. TRUE

NH_3 + H_2O ⇌ NH_4^+ + OH^-
Fe^{2+} + $2OH^-$ ⇌ **$Fe(OH)_2$** (green ppt formed)

On standing in air
O_2 + $4H^+$ + $4e^-$ ⇌ $2H_2O$ $E^\ominus$ = +1.23 V
Fe^{3+} + e^- ⇌ Fe^{2+} $E^\ominus$ = +0.77 V
Ecell = +1.23 – (+0.77)
= +0.46V
Reaction is feasible. Fe^{2+} oxidised to yellow Fe^{3+}.

22 An electrochemical cell consisting of a Ni^{2+}/Ni half-cell and a Fe^{3+}/Fe^{2+} half-cell was set up as shown below:



What change to the cell conditions leads to a higher cell potential?

	A	Add nickel (II) chloride to the Ni^{2+}/Ni half-cell.
	B	Add aqueous cyanide ions to the Fe^{3+}/Fe^{2+} half-cell.
	C	Add water to the Ni^{2+}/Ni half-cell.
	D	Increases the surface area of iron immersed in the solution.

Ans: C

For a spontaneous electrochemical cell, $E_{cell} = E_{Fe^{3+}/Fe^{2+}} - E_{Ni^{2+}/Ni}$

Option **A** is incorrect as

$$Ni^{2+} + 2e^- \rightleftharpoons Ni$$

When nickel (II) chloride is added to the nickel half-cell, $[Ni^{2+}]$ increase, eqm position shift right. $E_{Ni^{2+}/Ni}$ is more positive => E_{cell} should decrease.

Option **B** is incorrect as

$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+} \quad +0.77$$

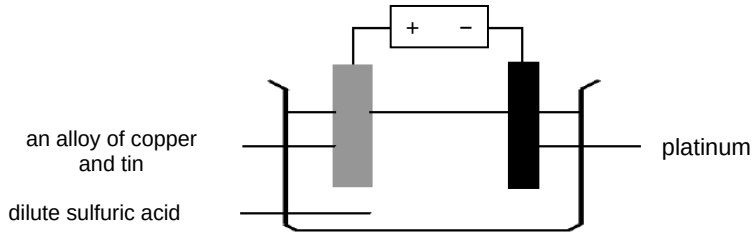
$$[Fe(CN)_6]^{3-} + e^- \rightleftharpoons [Fe(CN)_6]^{4-} \quad +0.36$$

When aqueous cyanide ions is added to the iron half-cell. $E_{Fe^{3+}/Fe^{2+}}$ is less positive => E_{cell} should decrease.

Option **C** is correct as when water is added to the nickel half-cell, $[Ni^{2+}]$ decrease, eqm position shift left. $E_{Ni^{2+}/Ni}$ is less positive => E_{cell} should increase.

Option **D** is incorrect as increases in the surface area of iron affects rate not E values.

23 The circuit shown in the diagram was set up.



Which reactions will occur at the electrodes at the start of electrolysis?

	anode reaction	*cathode reaction*
A	Oxygen gas is evolved.	Hydrogen gas is evolved.
B	Tin dissolves preferentially.	Hydrogen gas is evolved.
C	Copper dissolves preferentially.	Copper is deposited.
D	Copper and tin both dissolve.	Sulfur dioxide gas is evolved.

Ans: B

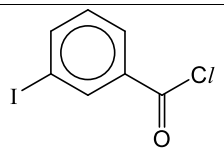
At the anode: (oxidation will occur)
Species present: Cu and Sn
Consider
$Sn^{2+} + 2e^- \longrightarrow Sn$ $\quad E^\ominus$/ **V** = - 0.14
$Cu^{2+} + 2e^- \longrightarrow Cu$ $\quad E^\ominus$/ **V** = +0.34
Based on the $E^\ominus$/ **V** values, a less positive value indicates that tin will be selectively oxidised.

At the cathode: (reduction will occur)
Species present: H_2O and H^+
Consider
$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$ $\quad E^\ominus$/ **V** = –0.83
$2H^+ + 2e^- \longrightarrow H_2$ $\quad E^\ominus$/ **V** = 0.00
$Sn^{2+} + 2e^- \longrightarrow Sn$ $\quad E^\ominus$/ **V** = - 0.14
Based on the $E^\ominus$/ **V** values, a more $E^\ominus$/ **V** positive value indicates that H^+ will be selectively reduced to produce H_2 gas.

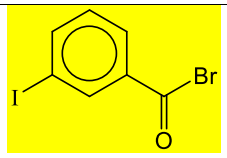
24 Excess aqueous sodium hydroxide was added into a test tube containing 1 mole of each of the compounds below at room temperature. After 10 minutes, excess HNO_3 was added. Excess aqueous silver nitrate was then added to the mixture.

Which compound will produce the largest mass of silver halide precipitate?

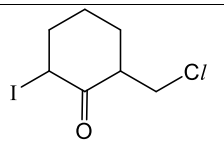
A



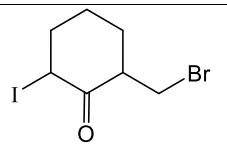
B



C



D



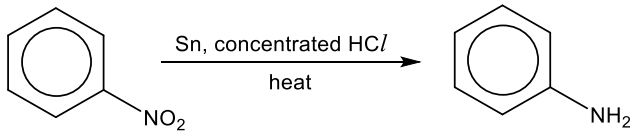
Ans: B

At room temperature, only the acyl chloride and acyl bromide will react instantaneously with the H_2O and OH^-, releasing Cl^- and Br^- respectively. Halogenoalkane requires heat for nucleophilic reactions to occur.

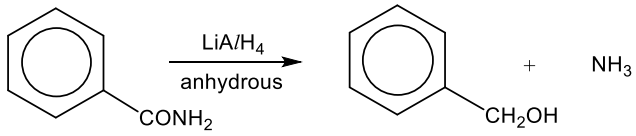
Hence, only **A** an **B** will give precipitate with silver nitrate. 1 mole of AgBr and AgCl is expected to be formed. Since AgBr has a higher Mr than AgCl, AgBr would have a larger mass produced.

25 Which reaction has the correct reagents and conditions for forming the respective organic compounds?

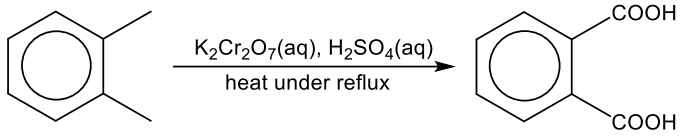
A



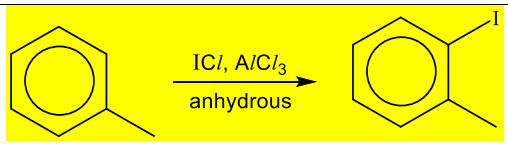
B



C

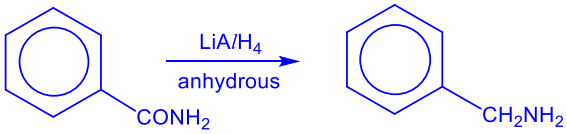


D



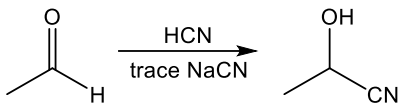
Ans: D

A: NaOH(aq) should be added to get the amine product from the protonated salt.
B: $LiAlH_4$ reduction of amide will give an amine.



C: A stronger oxidising agent, $KMnO_4$, should be used for side chain oxidation instead.
D: Correct answer as I is less electronegative than Cl and hence I^+ is the electrophile in the electrophilic substitution reaction.

26 Aldehydes can undergo a reaction with HCN to form a halohydrin.

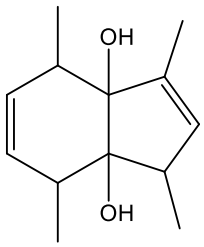


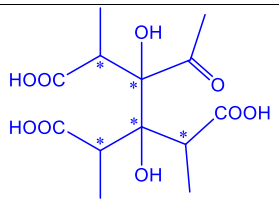
Which statements are true?

	1	The reaction will proceed with the addition of NaCN to the aldehyde, followed by drop-wise addition of aqueous sulfuric acid at room temperature.
	2	The reaction proceeds via nucleophilic addition, followed by reduction.
	3	The resultant solution from the reaction is optically active.
	A	1 only
	B	1 and 2
	C	1 and 3
	D	2 and 3
	1: When strong acid is added to cyanide ion, HCN is formed. $H^+ + CN^- \rightleftharpoons HCN$ with the existing NaCN, nucleophilic addition can occur. **2**: Step 1 is nucleophilic addition, but the 2nd step is an acid–base reaction, not reduction. **3**: As the aldehyde is attacked from the top and bottom plane with equal probability via nu addition, the product formed will be a racemic mixture and hence optically inactive.	

Commented [A.1]: Original: Product

Ambiguous, product can be the mixture or just the enantiomer. Putting molecule probably clearer?

27	The following molecule is reacted with hot acidified $KMnO_4$.  What is the possible number of stereoisomers that the product molecule can have?						
	A	2^3	**B**	2^4	**C**	2^5	**D** 2^6
	Ans: C After reaction with hot acidified $KMnO_4$,						



With 5 chiral centres, 2^5 possible stereoisomers can be formed.

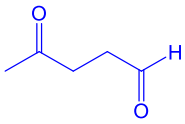
28 Compound **P**, $C_5H_8O_2$ is optically active and produces a yellow precipitate when heated with aqueous alkaline iodine. Brick-red precipitate is formed when **P** is warmed with alkaline solution of copper(II) tartrate.

What could be the identity of **P**?

A	$CH_3COCH_2CH_2CHO$
B	$CH_3COCH(CH_3)CHO$
C	$CH_3COOCH_2CH{=}CH_2$
D	$CH_3CH(OH)COCH{=}CH_2$

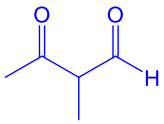
Ans: B

A



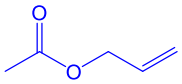
Molecule is not optically active.

B



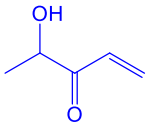
Matches all properties stated.

C



Not optically active.
Does not react with iodoform

D

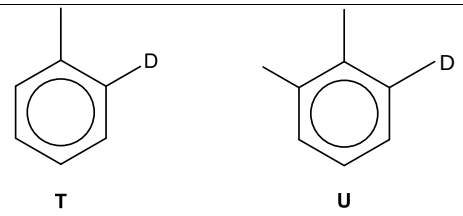


Does not react with Fehling's

29 Deuterium, D, is a heavy isotope of hydrogen that can be used for molecular labelling in mechanistic studies.

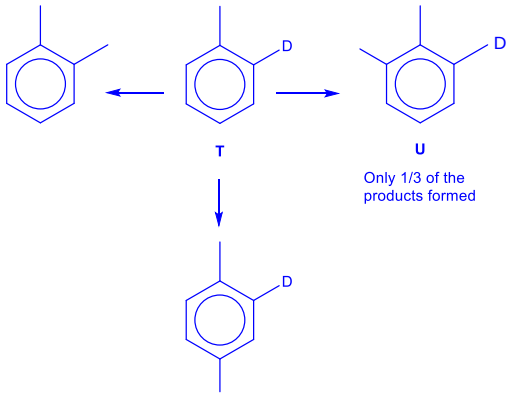
When compound **T** was completely reacted with bromomethane and $FeBr_3$, a mixture of products was formed.

Assuming that the carbon-deuterium bond is broken as easily as a carbon-hydrogen bond, what is the expected proportion of compound **U** in the mixture?



A	33%	**B**	50%	**C**	67%	**D**	100%

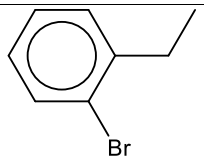
Ans: A



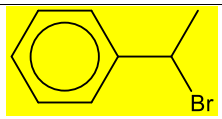
30 Ethylbenzene when heated with liquid bromine produced a mixture of products.

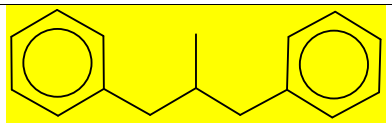
Which molecules are possible products from the reaction?

1



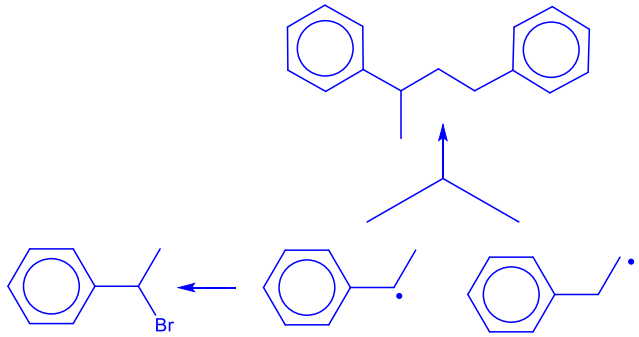
2



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

Ans: D

By heating ethyl benzene with liquid bromine, 2 alkyl radicals are formed.



2 radicals are formed from the heating