ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY **9729/01**
Higher 2

Paper 1 Multiple Choice

29 August 2018
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 fluids.
Write your name, index number and tutorial class 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.

This document consists of **18** printed pages.

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

1 The Basic Oxygen steel-making process is a method of preparing steel from carbon-rich molten pig iron. The process is basic because chemical bases are added to remove impurities. One such impurity is phosphorus pentoxide, P_4O_{10}. Calcium oxide, CaO, is added to remove it and the only product of the reaction is the salt, calcium phosphate, $Ca_3(PO_4)_2$.

How many moles of CaO reacted with one mole of P_4O_{10} in this reaction?

A 1

B 1.5

C 3

D 6

$P_4O_{l0} + 6CaO \rightarrow 2Ca_3(PO_4)_2$

Given that Ca_3PO_4 is the only product, write the balanced equation between P_4O_{10} and CaO to form Ca_3PO_4. Based on mole ratio, 6 moles of CaO is required to completely react with one mole of P_4O_{l0}.

Answer: **D**

2 Two moles of an oxidising agent, XO_4^- in the presence of excess acid oxidised 96 dm^3 of nitrogen dioxide gas at room temperature and pressure to NO_3^-.

What is the number of moles of electrons accepted by one mole of XO_4^-?

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

$n(NO_2) = 96/24 = 4$

$NO_2 + H_2O \rightarrow NO_3^- + 2H^+ + e$

$XO_4^- \equiv NO_2$

2 : 4

1 : 2

2 mol of NO_2 donate 2 mol of e which is accepted by 1 mol of XO_4^-

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

The ion $\mathbf{T}^+$ contains 28 electrons and 35 neutrons.

Which of the following statements about $\mathbf{T}^+$ or **T** is correct?

A **T** and Ga^{3+} are isoelectronic species.

B The elemental form of **T** can be oxidised by chlorine.

C The electronic configuration of $\mathbf{T}^+$ ion is $1s^22s^22p^63s^23p^63d^94s^1$.

D The angle of deflection of $^{27}Al^{3+}$ is approximately three times that of $\mathbf{T}^+$ in an electric field.

Since ion $\mathbf{T}^+$ contains 28 electrons, element **T** is copper which contains 29 electrons.

Option A is wrong as Ga^{3+} has 28 electrons, hence **T** and Ga^{3+} do not have the same number of electrons.

Option B is correct as Cu can be oxidised to Cu^{2+} by chlorine.
$Cu^{2+} + 2e \rightleftharpoons Cu \quad E^\ominus = +0.34\ V$
$Cl_2 + 2e \rightleftharpoons 2Cl^- \quad E^\ominus = +1.36\ V$
$E^\ominus_{cell} = +1.36 - (+0.34) = +1.02\ V$

Option C is wrong as the electronic configuration of $\mathbf{T}^+$ ion is $1s^22s^22p^63s^23p^63d^{10}$.

Option D is wrong as the angle of deflection of $^{27}Al^{3+}$ is not approximately three times that of $\mathbf{T}^+$ in an electric field.

The angle of deflection depends on the charge-to-mass ratio of the particles.

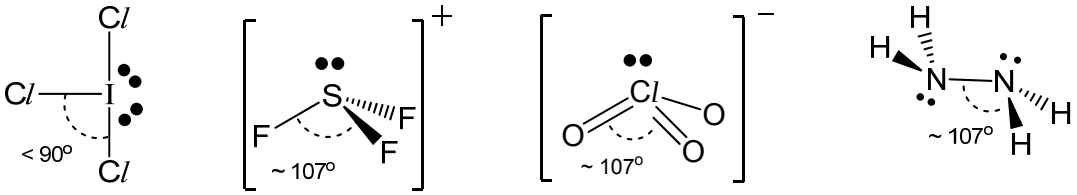
Angle of deflection of $Al^{3+} = k(\frac{3}{27}) = 0.111\ k$

Angle of deflection of $\mathbf{T}^+ = k(\frac{1}{64}) = 0.0156\ k$

Answer: **B**

4 Which of the following species has a different bond angle from the rest?

A ICl_3 **B** SF_3^+ **C** ClO_3^- **D** N_2H_4



Answer: **A**

5 What will happen to the volume of a bubble of air submerged in water under a lake at 10.0 ^{o}C and 2.00 atm if it rises to the surface where the temperature is 20.0 ^{o}C and the pressure is 1.00 atm?

A The volume will increase by a factor of 2.00.

B The volume will increase by a factor of 2.07.

C The volume will decrease by a factor of 2.00.

D The volume will decrease by a factor of 1.93.

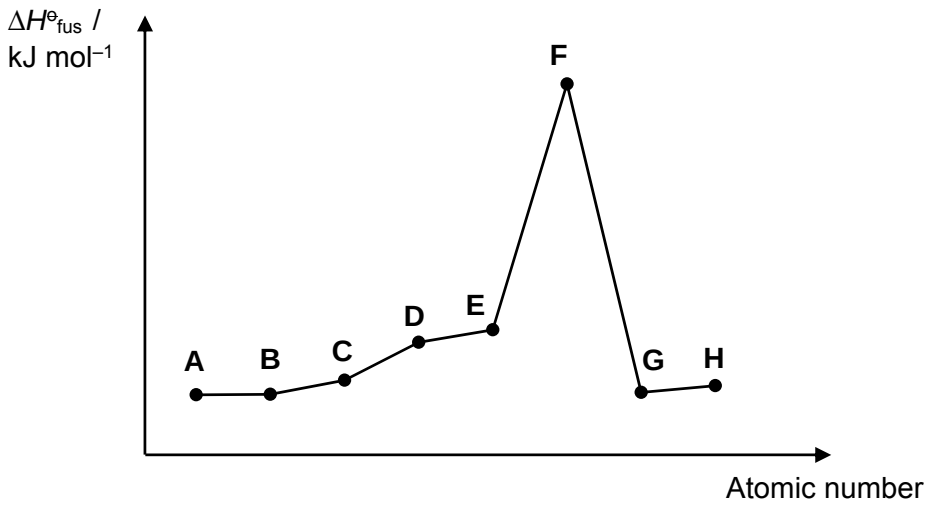
Answer : **B**

$P_1V_1/T_1 = P_2V_2/T_2$
$2(V_1)/ (273+10) = 1 (V_2) / (273 + 20)$

$V_2 = 293 \times (2) \times V_1 / 283 = 2.07\ V_1$

6 The graph below shows the variation in the standard enthalpy change of fusion, $\Delta H^{\ominus}_{fus}$ for 8 consecutive elements from period 2 to 3 in the periodic table.

Standard enthalpy change of fusion is the heat absorbed when one mole of a substance changes its state from solid to liquid under standard conditions.



Which of the following statements is true based on the information deduced from the above graph?

A The chlorides become more acidic from **A** to **C**.

B An oxide of **E** dissolves in water to form an alkaline solution.

C Element **G** has a higher first ionisation energy than element **F** and **H**.

D Element **D** has a lower electrical conductivity as compared to element **F**.

Since **F** is an element from period 2 to 3, and it has the largest $\Delta H^{\ominus}_{fus}$ (the rest of the elements have much lower $\Delta H^{\ominus}_{fus}$), **F** must be Si. Si has a giant covalent structure with high melting point and $\Delta H^{\ominus}_{fus}$.

So **A** is fluorine, **B** is neon, **C** is sodium, **D** is magnesium, **E** is aluminium, **G** is phosphorus and **H** is sulfur.

Option A is wrong as sodium chloride is a neutral chloride and there is no chloride of fluorine (fluorine reacts with chlorine to form chlorine fluoride instead). There is no reaction between neon and chlorine.

Option B is wrong as aluminium oxide is insoluble in water.

Option C is correct as phosphorus has a higher first ionisation energy than silicon and sulfur.

Option D is wrong as magnesium has a higher electrical conductivity as compared to silicon.

Answer: **C**

7 Some enthalpy changes of combustion are given below.

	ΔH_c / kJ mol^{-1}
CO(g)	–283
H_2(g)	–286
$CH_3OH(l)$	–715

What is the enthalpy change of the following reaction?

$$CO(g) + 2H_2(g) \longrightarrow CH_3OH(l)$$

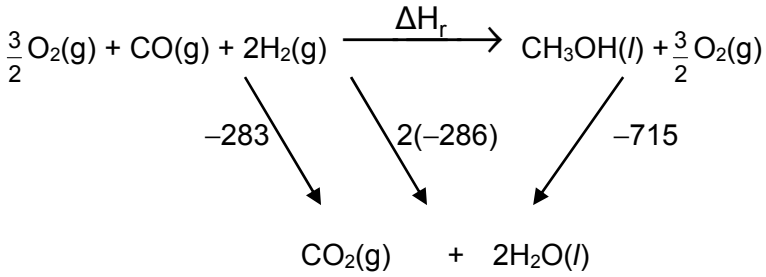
A –146

B +146

C –140

D +140

Answer: C



By Hess' law: $\Delta H_r = \Delta H_c$ *(reactants)* - ΔH_c *(products)*

= –283 + 2(–286) – (–715) = **–140** kJ mol^{-1}

8 The reaction of nitrogen monoxide and hydrogen gas

$$2NO(g) + 2H_2(g) \longrightarrow N_2(g) + 2H_2O(g)$$

is thought to involve the following steps:

I $NO + NO \rightleftharpoons N_2O_2$ (fast)

II $N_2O_2 + H_2 \longrightarrow H_2O + N_2O$ (slow)

III $N_2O + H_2 \longrightarrow N_2 + H_2O$ (fast)

Which of the following about the reaction is true?

A H_2 acts as the catalyst.

B The rate equation for the reaction is rate = $k[N_2O_2][H_2]$.

C The overall order of the reaction is 3.

D Increasing the concentration of NO does not change the rate of reaction.

Answer: C

A is incorrect as there is insufficient information to deduce that H_2 is the catalyst.

B is incorrect.

Based on the slow step:

Rate = k $[N_2O_2]$ $[H_2]$

However, N_2O_2 is not present in the final equation, this show that it is an intermediate and should not be present in the rate equation.

Based on step I,

$[N_2O_2]$ α k'$[NO]^2$

Rate = k'$[NO]^2[H_2]$

C is correct.

Based on the rate equation, overall order is 3.

D is incorrect. Since NO is present in the rate equation, increasing the concentration will increase the rate of reaction

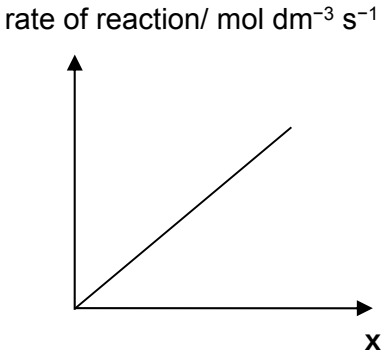
9 Hydrogen peroxide reacts with acidified iodide ions liberating iodine according to the equation below:

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow I_2(aq) + 2H_2O(l)$$

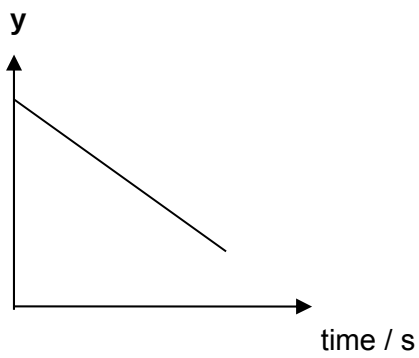
The kinetics of this reaction was investigated and it was found to have the following rate equation: rate = k $[H_2O_2]$ $[I^-]$

Two series of experiments were conducted, giving rise to **Graph A** and **Graph B**.

Graph A



Graph B



Which of the following shows the correct labelling of the x-axis for **Graph A** and y-axis for **Graph B**?

	x-axis	y-axis
A	$[H_2O_2]$ $[I^-]$ / mol^2 dm^{-6}	$[H^+]$ / mol dm^{-3}
B	$[H^+]$ / mol dm^{-3}	$[H_2O_2]$ / mol dm^{-3}
C	$[H_2O_2]$ $[I^-]$ / mol^2 dm^{-6}	$[I^-]$ / mol dm^{-3}
D	$[H^+]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}

Answer: A

Graph A:

As the rate eqn is rate = k $[H_2O_2]$ $[I^-]$

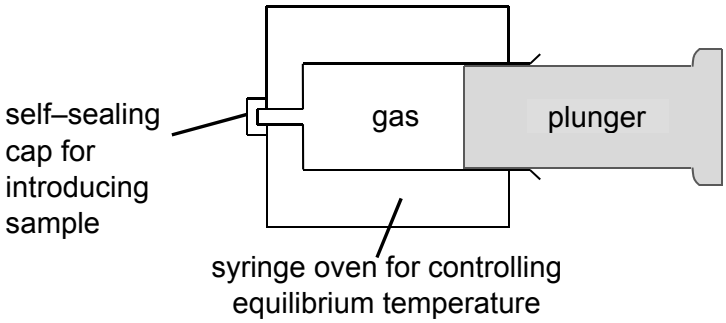
If y = mx , then y axis = rate

x-axis is $[H_2O_2]$ $[I^-]$

Graph B: It shows a zero order concentration-time graph (constant rate/grad), it is first order wrt to $[H_2O_2]$ and $[I^-]$. It is zero order wrt to $[H^+]$.

10 A gaseous dimer, **Z**, is introduced into an empty gas syringe which has a movable, tightly–fitting plunger. The gas is allowed to expand until equilibrium is reached at a controlled temperature at which 20 % of **Z** dissociates into its monomer **W**.

$$\mathbf{Z}(g) \rightleftharpoons 2\mathbf{W}(g)$$



Which of the following statements is correct?

A The forward reaction is exothermic.

B The value of the equilibrium constant, K_p is 0.167 atm.

C The pressure inside the syringe at equilibrium will be higher than the atmospheric pressure.

D The dissociation of dimer **Z** will be favoured when the plunger is pushed back into the equilibrium mixture.

Answer: **B**

Option A

The dissociation of a dimer only involves “bond breaking” and thus is an endothermic process.

Option B

Let the initial amount (mol) of **X** be ‘a’

$$\mathbf{X}(g) \rightleftharpoons 2\mathbf{W}(g)$$

Initial/mol	a	0
Change/mol	–0.2a	+0.4a
Eqm/mol	0.8a	0.4a

P_W = (0.4a / 1.2a) x 1 atm = 1/3 atm

P_X = (0.8a / 1.2a) x 1 atm = 2/3 atm

$K_p = P_W^2 / P_X = (1/3)^2 / (2/3) = 1/6$ atm = 0.167 atm

Option C

The final pressure inside the syringe will have to be the same as atmospheric pressure (1 atm) to ensure that the syringe stops moving.

Option D

Pushing the plunger back will decrease volume, and thus cause the pressure of the system to increase.

Based on Le Chatelier's Principle, equilibrium position will shift to the left which has lesser gaseous particles to reduce the pressure. Thus association of **W** is favoured.

11 The acid dissociation constants for the diprotic acid, malonic acid $H_2C_3H_2O_4$ are K_{a1} = 1.5 x 10^{-3} and K_{a2} = 2.0 x 10^{-6}.

What is K_b for $HC_3H_2O_4^-$?

A $K_w \times K_{a1}$

B $K_w \times K_{a2}$

C K_w / K_{a1}

D K_w / K_{a2}

Answer: **C**

$H_2C_3H_2O_4 \rightleftharpoons HC_3H_2O_4^- + H^+$ $K_{a1} = 1.5 \times 10^{-3}$

$HC_3H_2O_4^- \rightleftharpoons C_3H_2O_4^{2-} + H^+$ $K_{a2} = 2.0 \times 10^{-6}$

Measurement for K_b, $HC_3H_2O_4^-$ would be acting as a base accepting proton

$HC_3H_2O_4^- + H^+ \rightleftharpoons H_2C_3H_2O_4$

$K_w = K_{a1(H_2C_3H_2O_4)} \times K_{b(HC_3H_2O_4^-)}$ ($H_2C_3H_2O_4$ and $HC_3H_2O_4^-$ are conjugate acid-base pair)

$K_{b(HC_3H_2O_4^-)} = K_w / K_{a1(H_2C_3H_2O_4)}$

12 Hardness in tap water can be determined by titrating a sample against a reagent which forms complex ions with dissolved metal ions. The indicator for this titration requires the pH to be maintained at about 10.

Which of the following, in aqueous solution, could be used to do this?

A 10 cm^3 of 2.0 g dm^{-3} of sodium hydroxide neutralised by 10 cm^3 of 0.025 mol dm^{-3} of ethanoic acid

B 5 cm^3 of 1.7 g dm^{-3} of ammonia neutralised by 10 cm^3 of 0.025 mol dm^{-3} hydrochloric acid

C 20 cm^3 of 0.05 mol dm^{-3} of hydrochloric acid neutralised by 5 cm^3 of 1.7 g dm^{-3} ammonia

D 10 cm^3 of 0.05 mol dm^{-3} of ethanoic acid neutralised by 5 cm^3 of 2.0 g dm^{-3} of sodium hydroxide

Answer: **B**

To maintain solution at pH10 we need basic buffer which is made of weak base and its salt

Option (A) is made of sodium hydroxide (strong acid) and sodium ethanoate salt

Option (B) is made of ammonia and ammonium chloride (weak base and its salt)

Option (C) is made of hydrochloric acid and ammonium chloride

Option (D) is made up of ethanoic acid and sodium ethanoate

13 The solubility product of some sparingly soluble lead compounds are shown below. Which compound will have the lowest concentration of Pb^{2+} (aq) ions in a saturated solution?

	compound	numerical value of solubility product (at 25 ^oC)
A	lead(II) fluoride	2.7×10^{-8}
B	lead(II) bromide	4.0×10^{-5}
C	lead(II) iodide	7.1×10^{-9}
D	lead(II) sulfate	1.6×10^{-8}

For the lead halides, $K_{sp} = [Pb^{2+}][X^-]^2$ where X = F, Br or I

Let $[Pb^{2+}]$ be x mol dm^{-3}

Hence $[X^-]$ is 2x mol dm^{-3}

Ksp is hence $4x^3$

For $PbBr_2$, $[Pb^{2+}] = 0.0215$ mol dm^{-3}

For PbF_2, $[Pb^{2+}] = 1.89 \times 10^{-3}$ mol dm^{-3}

For PbI_2, $[Pb^{2+}] = 1.21 \times 10^{-3}$ mol dm^{-3}

For $PbSO_4$, $K_{sp} = [Pb^{2+}][SO_4^{2-}]$.

Hence $[Pb^{2+}] = \sqrt{K_{sp}}$

$[Pb^{2+}] = 1.26 \times 10^{-4}$ mol dm^{-3}

Answer: **D**

14 Morphine is a powerful narcotic painkiller which could be isolated from opium poppy. Though it relieves pain effectively, it can cause addiction so readily that it should only be used in the cases where other pain medications are inadequate.

morphine

Which of the following claims about morphine is true?

1 There are 5 chiral carbons present in the molecule.

2 There are 7 C–C bonds formed by sp^3 – sp^3 overlap.

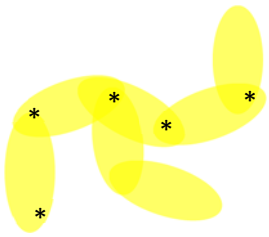
3 The molecule cannot exhibit cis-trans isomerism at the C=C double bond.

A 1 only

B 2 only

C 2 and 3 only

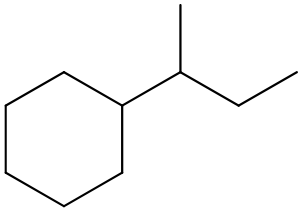
D 1, 2 and 3



There are 5 chiral carbons present in the molecule, indicated by the asterisks and there are 7 C–C bonds formed by sp^3 – sp^3 overlap, highlighted in the diagram. The molecule cannot exhibit cis-trans isomerism at the C=C double bond as the trans isomer could not exist.

Answer: **D**

15 Compound **L** reacts with limited chlorine gas in the presence of sunlight.



compound **L**, $C_{10}H_{20}$

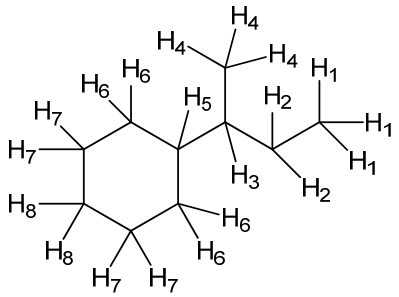
Assuming that only mono-chlorination takes place and ignoring the relative rates of abstraction of the different type of hydrogen atom, which of the following statements is **incorrect**?

A The maximum number of chlorinated products formed is 8.

B $C_{20}H_{38}$ is present in small quantities in the products.

C Homolytic fission occurs in both initiation and propagation step.

D The ratio of primary to secondary to tertiary chloroalkanes formed is 3:6:2.

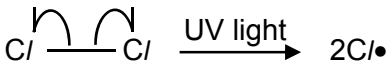


Option A is correct. The maximum number of chlorinated products formed is 8.

Option B is correct. Since compound **L** has the molecular formulae of $C_{10}H_{20}$, it can form a radical with the molecular formula of $C_{10}H_{19}$ in the first step of propagation. Hence two radicals of $C_{10}H_{19}$ can react in the termination step to form $C_{20}H_{38}$ as one of the side products.

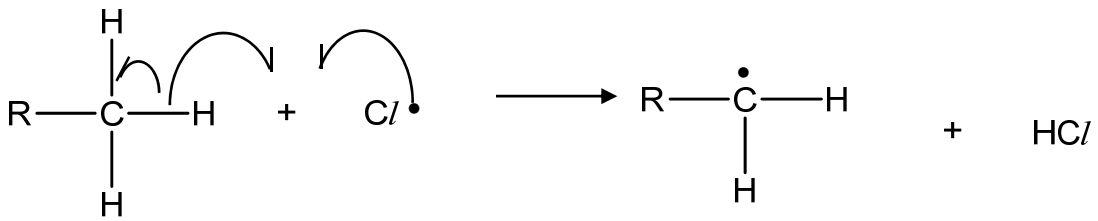
Option C is correct. Homolytic fission occurs in both initiation and propagation step.

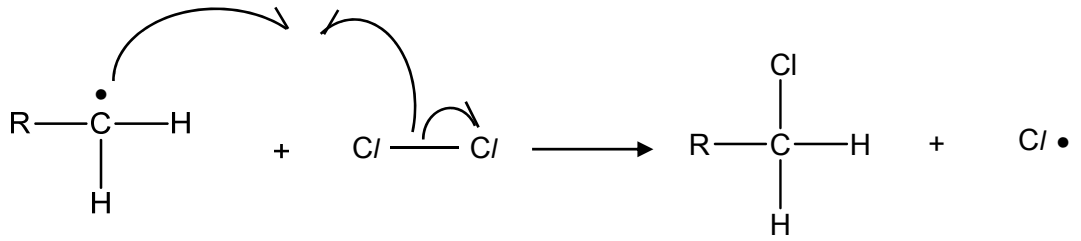
Initiation step:



Propagation step:

Let R be the rest of the molecule.





Option D is incorrect.

When H_1 and H_4 atoms are substituted (total of 6 hydrogen atoms), primary chloroalkanes will be formed.

When H_2, H_6, H_7 and H_8 atoms are substituted (total of 12 hydrogen atoms), secondary chloroalkanes will be formed.

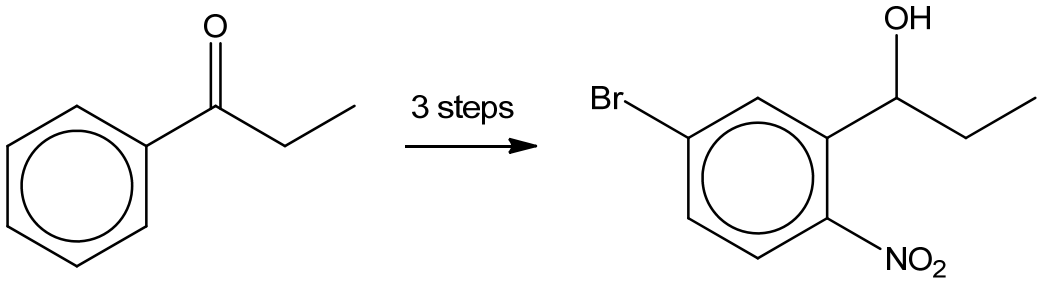
When H_3 and H_5 atoms are substituted (total of 2 hydrogen atoms), tertiary chloroalkanes will be formed.

Hence the ratio of primary to secondary to tertiary chloroalkanes formed is 6:12:2 => 3:6:1 instead of 3:6:2.

Answer: **D**

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

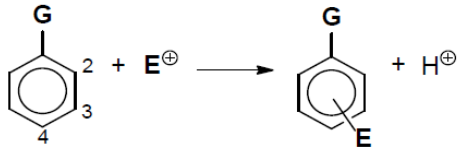
The following transformation takes place in three steps.



Which of the following shows the best choice of reagents and conditions to carry out the transformation?

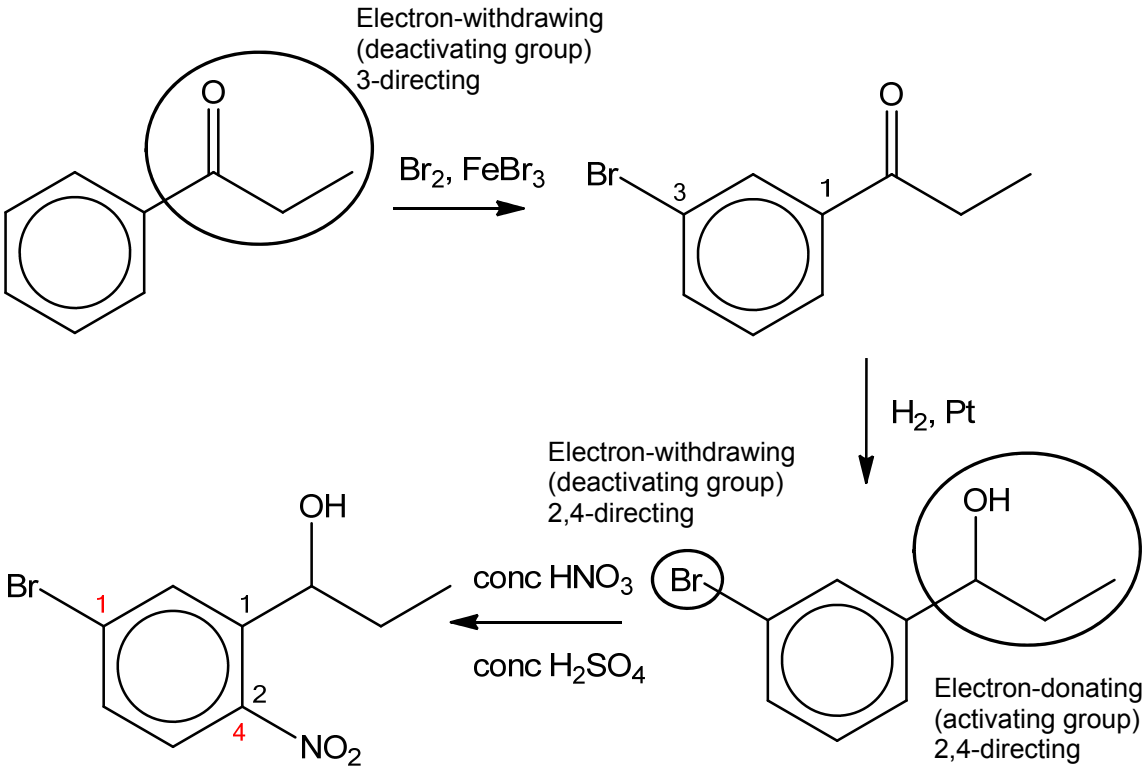
	step 1	step 2	step 3
A	H_2, Pt	conc HNO_3, conc H_2SO_4	Br_2, $FeBr_3$
B	Br_2, $FeBr_3$	H_2, Pt	conc HNO_3, conc H_2SO_4
C	H_2, Pt	Br_2, $FeBr_3$	conc HNO_3, conc H_2SO_4
D	Br_2, $FeBr_3$	conc HNO_3, conc H_2SO_4	H_2, Pt

The position of the incoming group, **E**, is determined by the nature of the group, **G**, already bonded to the ring, and not by the nature of the incoming group **E**.



G	–alkyl –OH or –OR $–NH_2$, –NHR or $–NR_2$ –NHCOR	–Cl, –Br, –I	–CHO, –COR $–CO_2H$, $–CO_2R$ $–NH_3^+$ $–NO_2$, –CN
Reactivity of ring (compared to benzene)	Activated	Deactivated	Deactivated
Position of E (relative to position of G)	2- and/or 4-	2- and/or 4-	3-

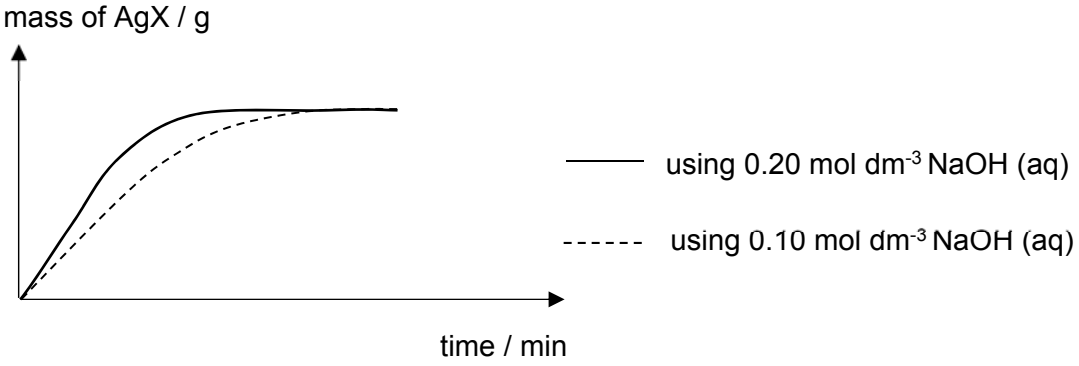
The circled groups will be needed to decide the correct way of transformation in this question.



Note that $-NO_2$ group is an electron-withdrawing group and strong deactivating, it will direct incoming electrophile to the 3rd position relative to itself.

Answer: **B**

17 A halogen-containing compound, **U**, is heated with 2 different concentrations of aqueous sodium hydroxide. After acidifying the mixture and adding excess aqueous silver nitrate, the mass of silver halide formed is analysed over a period of time. The following graph for the mass of silver halide precipitate against time was obtained.



Which of the following is the likely structure of **U**?

A **B**

C **D**

The gradient of the graph gives the rates of reaction.

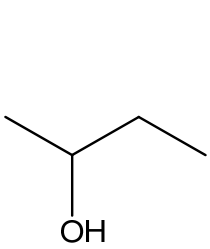
The graph shows that the rate of formation of the ppt increases when $[OH^-]$ increases from 0.10 M to 0.20 M. Hence the nucleophilic substitution of the alkyl halide involves OH^- in the slow step. (i.e. Compound U can undergo SN2 mechanism, so it must be primary or secondary alkyl halide)

A is a secondary alkyl halide, so its rate of reaction is affected by $[OH^-]$.
B is a tertiary alkyl halide, so its rate of reaction is not affected by $[OH^-]$.
C is a vinyl halide (halogen atom bonded to alkene functional group), so it is resistant to nucleophilic substitution.
D is a chloride salt, so it form silver halide ppt immediately.

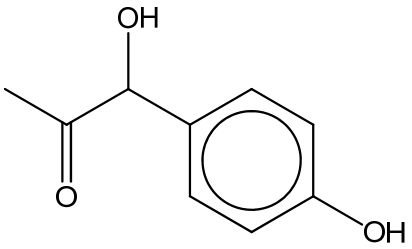
Answer: **A**

18 The following two compounds react with alkaline aqueous iodine to form yellow precipitate of tri-iodomethane as one of the products.

What is the ratio of sodium hydroxide used to react with 1 mol of compound **V** and 1 mol of compound **W** respectively?

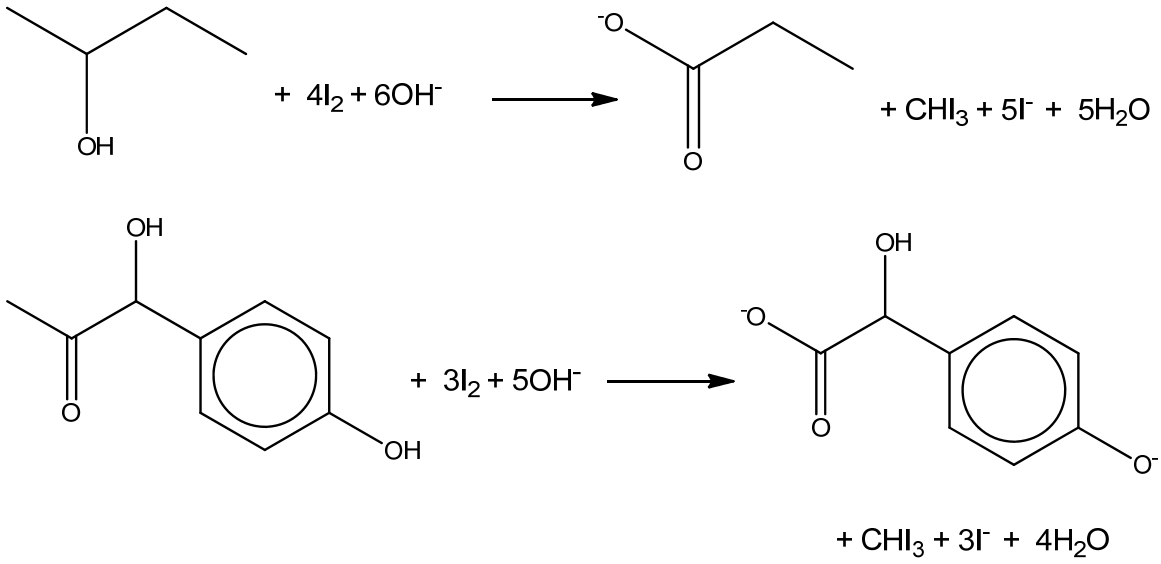


compound **V**



compound **W**

	compound **V**	compound **W**
A	4	4
B	4	6
C	6	4
D	6	5



Hence the ratio of sodium hydroxide used to react with 1 mol of compound **V** and 1 mol of compound **W** respectively is 6: 5.

Note that phenol is acidic enough to react with sodium hydroxide, but not alcohol.

Answer: **D**

19 A fresh salad with tomatoes may contain compound $CH_3CH_2CH_2CH=CHCHO$ which provides an aroma for tomatoes. What will be the final product, **P** in this sequence of reactions?

$$CH_3CH_2CH_2CH=CHCHO \xrightarrow[\text{then } H_2O]{NaBH_4 \text{ in } CH_3OH} \mathbf{O} \xrightarrow[\text{heat}]{K_2Cr_2O_7/H^+} \mathbf{P}$$

A $CH_3CH_2CH_2CH=CHCOOH$

B $CH_3CH_2CH_2CH_2CH_2COOH$

C $CH_3CH_2CH_2CH=CHCH_2OH$

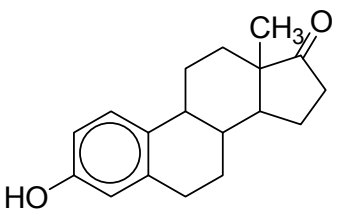
D $CH_3CH_2CH_2COOH$

In $CH_3CH_2CH_2CH=CHCHO$ the aldehyde group undergoes reduction by $NaBH_4$ to form primary alcohol group in P, $CH_3CH_2CH_2CH=CHCH_2OH$. The primary alcohol group in P is then oxidized to acid group in **Q** $CH_3CH_2CH_2CH=CHCOOH$ by $K_2Cr_2O_7/H^+$, heat

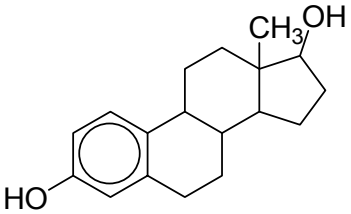
C=C is not reduced by $NaBH_4$ and not oxidized by $K_2Cr_2O_7/H^+$, heat

Answer: **A**

20 Two female sex hormones are oestrone and oestradiol.



oestrone



oestradiol

Which of the following reagents could be used to distinguish between the two hormones?

1 $SOCl_2$

2 $KMnO_4/H^+$

3 LiA/H_4 in dry ether

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

Answer: **D** (1 only is correct)

Option 1 (Correct)

$SOCl_2$ reacts with the secondary alcohol group in oestradiol to give white fumes of HCl. Oestrone does not have the secondary alcohol group.

Option 2 (Wrong)

Both can react with $KMnO_4$ due to the alkyl side chain of benzene, in addition to the secondary alcohol group in oestradiol.

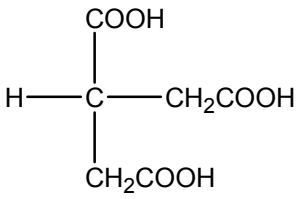
Option 3 (Wrong)

While $LiAlH_4$ reacts with the ketone group in oestrone and not with oestradiol, there is no way to distinguish based on absence of visible change.

21 Ethanoic acid can be made by direct carbonylation of methanol, in presence of a rhodium catalyst.

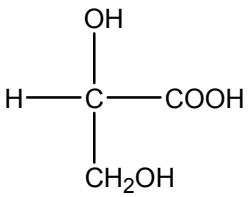
$$CH_3OH + CO \xrightarrow{\text{rhodium catalyst}} CH_3COOH$$

Which of the following can produce compound **S** using a similar method?

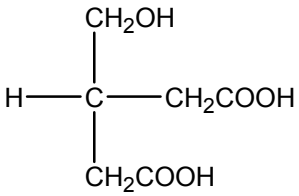


compound **S**

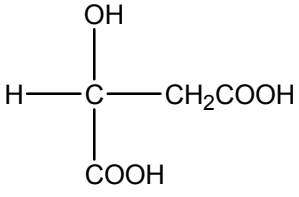
A



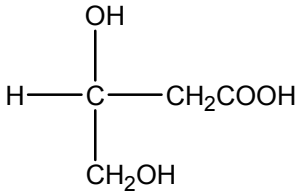
B



C



D

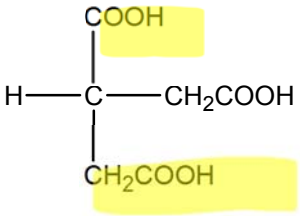


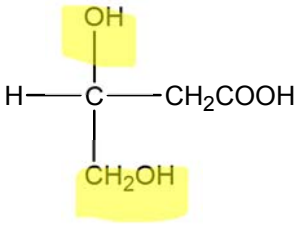
Answer: D

Pattern recognition of adding a CO between the C and O atom.

$$CH_3OH + CO \xrightarrow{\text{rhodium catalyst}} CH_3COOH$$

To form compound S,





22 Benzylamine has the formula $C_6H_5CH_2NH_2$ and is a common precursor in organic synthesis.

Which of the following statements about benzylamine is correct?

1 It reacts with excess CH_3CH_2Cl to form the compound, $C_{13}H_{22}NCl$.

2 It reacts with CH_3COOH to form $C_6H_5CH_2NHCOCH_3$.

3 It can be distinguished from $CH_3CH_2NH_2$ by the use of aqueous bromine.

A 1, 2 and 3

B 1 and 2 only

C 1 only

D 2 and 3 only

1 is correct

Benzylamine undergoes nucleophilic substitution with CH_3CH_2Cl to form a quarternary ammonium salt.

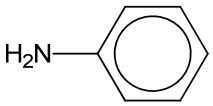
2 is incorrect

Benzylamine reacts with CH_3COOH to form an ionic salt.

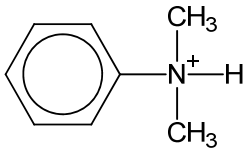
3 is incorrect

Both cannot decolourise bromine. Phenylamine will decolourise bromine but not benzylamine.

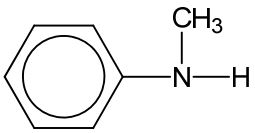
23 The structures of some nitrogen containing compounds are shown below.



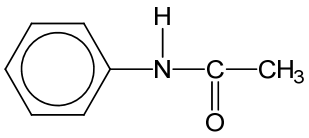
compound **H**



compound **I**



compound **J**



compound **K**

What is the order of increasing basicity of the nitrogen containing compounds?

	least basic → most basic			
A	**I**	**H**	**K**	**J**
B	**I**	**K**	**H**	**J**
C	**I**	**K**	**J**	**H**
D	**K**	**I**	**J**	**H**

Methyl group is electron donating and it increases the electron density on nitrogen in J

Lone pair of electrons on nitrogen in H is delocalised into the benzene ring , hence it is less available for accepting a proton.

K is a neutral compound as the lone pair of electrons on nitrogen is delocalised into C=O group.

I is an acidic compound due to salt hydrolysis, hence it is least basic.

24 *Use of Data Booklet is relevant to this question.*

Which statements about the elements chlorine, bromine and iodine are correct?

1 The oxidising power decreases from chlorine to iodine.

2 The bond length of the molecule increases from chlorine to iodine.

3 The magnitude of the first electron affinity increases from chlorine to iodine.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

Option 1 (Correct)

Down the group from chlorine to iodine, increasing shielding effect results in lower effective nuclear charge, hence less ability to attract electrons resulting in decreasing oxidizing power down the group

Option 2 (Correct)

Down the group, size of atoms increases resulting in less effective orbital overlap between two halogen atoms in a covalent bond and hence longer bond length of the molecule

Option 3 (Incorrect)

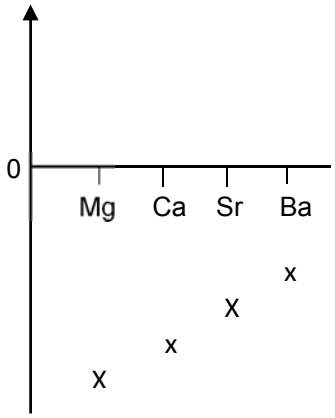
$X(g) + e^- \longrightarrow X^-(g)$

The magnitude of first electron depends on the effective nuclear charge which decreases as the shielding effect increases down the group from chlorine to iodine

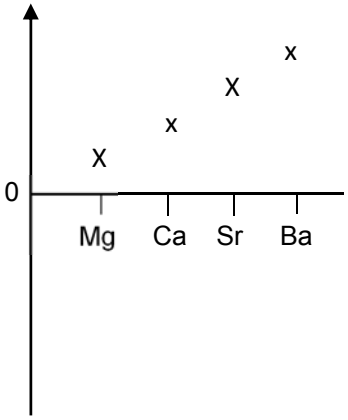
Answer: **A**

25 Which diagram correctly shows the trend in a property of the Group 2 elements Mg, Ca, Sr, Ba?

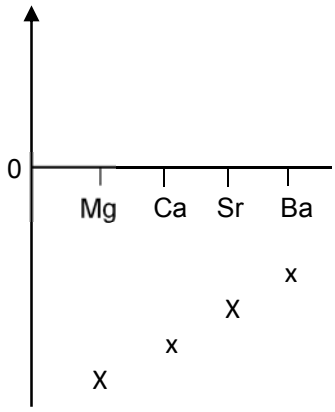
A ΔH_{hyd}, the enthalpy change of hydration of $M^{2+}(g)$



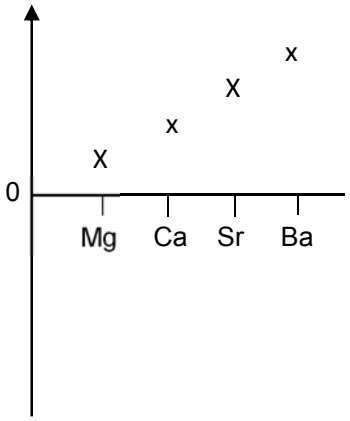
B *I*, the first ionisation energy



C $E^{\ominus}$, the standard electrode potential of $M^{2+}(aq)|M(s)$ electrode



D Electronegativity value



Enthalpy change of hydration is proportional to charge/radius of cation and it is an attraction force hence exothermic

As cation radii, increases from Mg^{2+} to Ba^{2+}, the enthalpy change of hydration becomes less exothermic.

Answer: **A**

26 Three half cells are constructed as follows.

Half cell **I**: an electrode of metal **Q** in a 1.0 M solution of $\mathbf{Q}^{+}(aq)$ ions

Half cell **II**: an electrode of metal **R** in a 1.0 M solution of $\mathbf{R}^{+}(aq)$ ions

Half cell **III**: an electrode of Cu metal in a 1.0 M solution of $Cu^{2+}(aq)$ ions

The half cells are connected in pairs, as shown below, to form a series of galvanic cells. For each cell, the polarity of the electrodes and the voltage generated are recorded.

half cells used	positive electrode	negative electrode	voltage (V)
I and **III**	Cu	**Q**	0.57
II and **III**	Cu	**R**	1.10
I and **II**	**Q**	**R**	0.53

Which one of the following lists the metals in order of **increasing** strength as reducing agents?

A **R**, **Q**, Cu

B **Q**, Cu, **R**

C Cu, **R**, **Q**

D Cu, **Q**, **R**

Answer: D

In a galvanic cell the reducing agent is oxidised; oxidation occurs at the anode; the anode is the negative electrode. In each cell the stronger reducing agent is at the negative electrode.

According to the data relative strength of the reducing agents are:

For half cells:

II and IV **Q** > Cu;

III and IV **R** > Cu;

II and III **R** > **Q**

Hence, the order of increasing strength of the reducing agents is Cu < **Q** < **R**

27 Some standard redox potential ($E^{\ominus}$) values are given in the table below.

electrode reaction	$E^{\ominus}$/ V
$Fe^{3+}(aq) + e \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Sn^{4+}(aq) + 2e \rightleftharpoons Sn^{2+}(aq)$	+0.15
$Ce^{4+}(aq) + e \rightleftharpoons Ce^{3+}(aq)$	+1.45

Which of the following reactions would occur under standard conditions?

1 $Ce^{4+}(aq) + Fe^{2+}(aq) \longrightarrow Ce^{3+}(aq) + Fe^{3+}(aq)$

2 $Sn^{2+}(aq) + 2Fe^{3+}(aq) \longrightarrow Sn^{4+}(aq) + 2Fe^{2+}(aq)$

3 $2Ce^{4+}(aq) + Sn^{2+}(aq) \longrightarrow 2Ce^{3+}(aq) + Sn^{4+}(aq)$

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

Answer: A

Checking for reactions 1,2 and 3:

Reaction 1: $E^{\ominus}_{cell}$= +1.45 – 0.77 = +0.68V

Reaction 2: $E^{\ominus}_{cell}$= +0.77 – 0.15 = +0.62 V

Reaction 3: $E^{\ominus}_{cell}$= +1.45 – 0.15 = +1.3V

All the values are >0, hence the reactions are all spontaneous.

28 A current was passed through two cells connected in series. The first cell contained molten sodium chloride while the other contained a molten aluminium salt.

What would be the mass of aluminium liberated from the other cell if 4.6g of sodium was liberated from the first cell?

A 0.9 g

B 1.8 g

C 2.7 g

D 3.6 g

Answer: B

Amt of electrons transferred in the two electrolytic cells is the same.

[R]: $Na^+ + e \rightarrow Na$ (s)

Amt of sodium = 4.6/23 = 0.2 mol

Amt of electrons = 0.2 mol

[R]: $Al^{3+} + 3e \rightarrow Al$ (s)

Amt of electrons transferred = 0.2 mol

Amt of Al = 0.2/3 = 0.06667 mol

Mass of Al = 0.06667 x 27 = 1.8g

29 Which of the following does **not** act as a ligand in the formation of complexes?

A SCN^-

B Cl^-

C AlH_4^-

D $C_2O_4^{2-}$

Out of all the species present, AlH_4^- has no available lone pairs of electrons for donation to form a dative covalent bond as all the electrons are used for bonding.

Answer: **C**

30 A reaction scheme starting from aqueous copper(II) sulfate solution is shown below. Both **X** and **Y** are copper-containing species.

$$CuSO_4(aq) \xrightarrow[\text{I}]{NH_3(aq)} \mathbf{X} \xrightarrow[\text{II}]{\text{excess } NH_3(aq)} \mathbf{Y} \xrightarrow[\text{III}]{Na_4edta(aq)} [Cu(edta)]^{2-}(aq)$$

Which of the following statements is true?

1 NH_3 acts as a ligand in reaction I.

2 Reaction II is a redox reaction.

3 The entropy of the system increases when reaction III occurs.

A 1 only

B 3 only

C 1 and 3 only

D 1, 2 and 3 only

In reaction I, NH_3 is acting as a weak base to generate OH^- a to form the ppt **X.** NH3 only acts as a ligand in reaction II.

In reaction II, it is a ligand exchange reaction, hence there is no change in the oxidation state of the metal centre.

$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$

Oxidation state of the Cu centre is still +2.

In reaction III, edta displaces the NH_3 and H_2O ligands.

$[Cu(NH_3)_4(H_2O)_2]^{2+} + edta^{4-} \rightleftharpoons [Cu(edta)]^{2-} + 4NH_3 + 2H_2O$

There is an increase in the number of particles from 2 to 7 after the reaction and hence the entropy of the system increases in reaction III.

Answer: **B**