

ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC2 PRELIMINARY EXAMINATION Paper 1 Solutions

- 1 Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

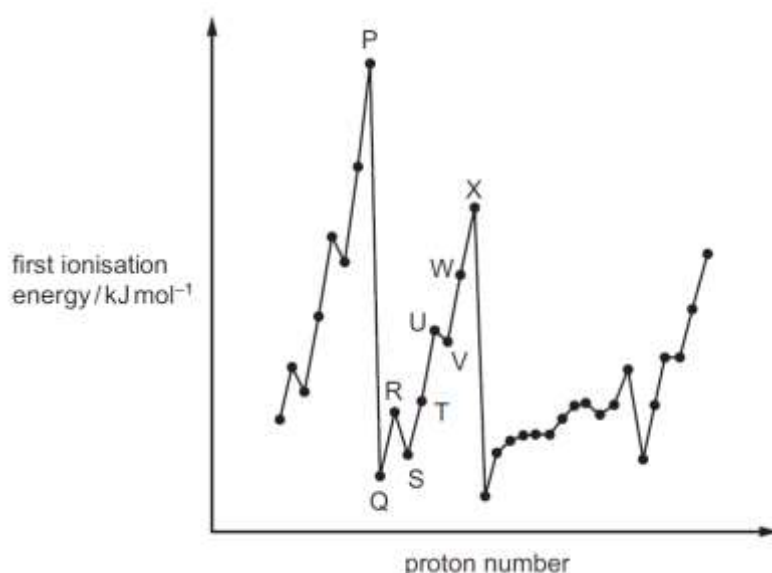
What are the number of electrons in the sodium ion and the azide ion?

	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

Ans: B

Na^+ ($11 - 1 = 10$) and N_3^- ($7 \times 3 + 1 = 22$)

- 2 The graph shows the variation of the first ionisation energy with proton number for some elements. The letters used are not the actual symbols for the elements.



Which statement about the elements is correct?

- A** P and X are in the same period in the Periodic Table.
- B** The general increase from Q to X is due to increasing atomic radius.
- C** The small decrease from R to S is due to decreased shielding.
- D** The small decrease from U to V is due to repulsion between paired electrons.

Ans: D

A – same Group

B – increasing nuclear charge (and relatively constant shielding effect)

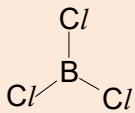
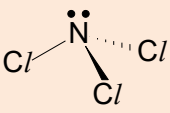
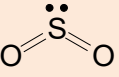
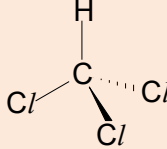
C – higher energy level (ns^2 vs np^1)

- 3 The table identifies the shape and polarity of four molecules.

Which row is correct?

	molecule	molecular shape	polarity
A	boron trichloride	trigonal pyramidal	polar
B	nitrogen trichloride	trigonal planar	non-polar
C	sulfur dioxide	bent	polar
D	trichloromethane	tetrahedral	non-polar

Ans: C

	BCl_3	NC_3	SO_2	$CHCl_3$
No. of bp, lp on central atom	3 bp, 0 lp	3 bp, 1 lp	2 bp, 1 lp	4 bp, 0 lp
Molecular shape	trigonal planar 	trigonal pyramidal 	bent 	tetrahedral 
polarity	non-polar	polar	polar	polar

- 4 The element tin exists in two forms, grey tin and white tin.

Some properties of grey tin and white tin are shown.

	grey tin	white tin
boiling point	2543 °C	2533 °C
electrical conductivity	none in solid or liquid	good in solid and liquid
malleability	brittle	malleable

Which structural change might take place when grey tin changes to white tin?

- A** giant covalent to giant ionic
- B** giant covalent to giant metallic
- C** giant ionic to giant covalent
- D** giant ionic to giant metallic

Ans: B

White tin must have giant metallic structure as it conducts electricity in solid and liquid state and its malleable.

Grey tin cannot have giant ionic structure as it does not conduct electricity when in liquid state, thus, it has to be giant covalent structure.

- 5 0.01 mol of KIO_n reacts with 0.05 mol of KI stoichiometrically to produce I_2 under acidic conditions. In this reaction, all the iodine containing reactants were converted to I_2 .

What is the value of n?

- A 1
B 2
C 3
D 4

Ans: C

Let the oxidation state of iodine in KIO_n be I^{n+}

(this approach allow you to focus on the species that is undergoing Redox.)

Reduction: $(2n) e + 2 \text{I}^{n+} \rightarrow \text{I}_2$ x 2

Oxidation: $2\text{I}^- \rightarrow \text{I}_2 + 2e$ x 2n

Overall equation: $4\text{I}^{n+} + (4n)\text{I}^- \rightarrow 2\text{I}_2 + (2n)\text{I}_2$

Comparing mole ratio $\frac{\text{amt of I}^{n+}}{\text{amt of I}^-} = \frac{4}{4n} = \frac{0.01}{0.05}$,

solving n = 5

Since IO_n^- , considering the oxidation number and overall charges of the ion,

$+5 + n(-2) = -1$

n = 3

OR

IO_n^- : I^-

1 : 5

oxidation: $2\text{I}^- \rightarrow \text{I}_2 + 2e^-$

$5\text{I}^- \rightarrow \frac{5}{2}\text{I}_2 + 5e^-$

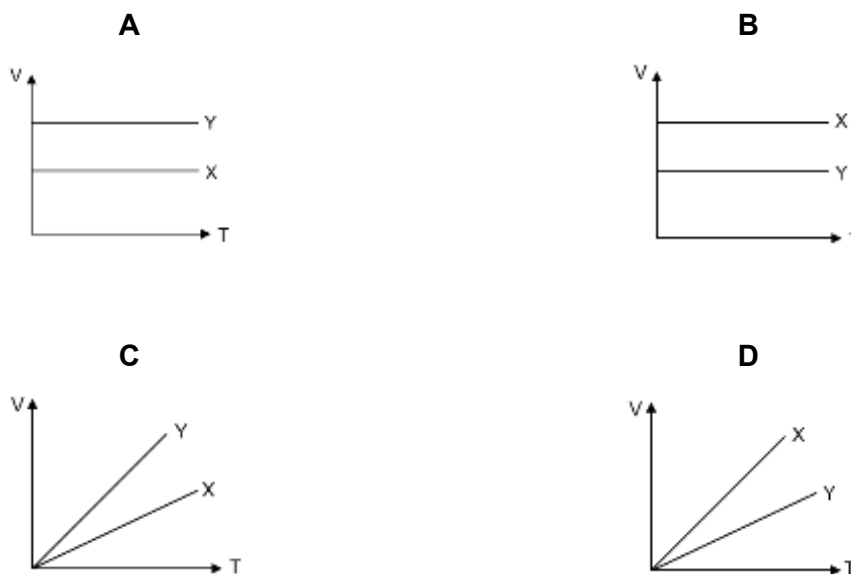
[R]: $2\text{IO}_n^- + 4n\text{H}^+ + (4n-2)e^- \rightarrow \text{I}_2 + 2n\text{H}_2\text{O}$

$2n - 1 = 5$

n = 3

- 6 X and Y are two different samples of the same ideal gas.

Given that X contains a higher mass than Y, which graph shows the correct ideal gas relationship for the two samples of gas? (T is measured in K.)



Ans: D

Manipulation of ideal gas equation would give

- $V = \frac{mR}{pM}(T) \Rightarrow$ graph of V against T gives a straight line passing thru the origin. [option D]

Since X has a larger mass, the line for X has a steeper gradient.

- 7 A student mixes 25.0 cm^3 of $0.350 \text{ mol dm}^{-3}$ sodium hydroxide solution with 25.0 cm^3 of $0.350 \text{ mol dm}^{-3}$ hydrochloric acid. The temperature increases by 2.5°C . No heat is lost to the surroundings.

The final mixture has a specific heat capacity of $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.

What is the molar enthalpy change for the reaction?

- A -150 kJ mol^{-1}
 B -60 kJ mol^{-1}
 C -30 kJ mol^{-1}
 D $-0.15 \text{ kJ mol}^{-1}$

Ans: B

Limiting reagent is hydrochloric acid = $(0.35 \times 0.025) = 0.00875 \text{ mol}$

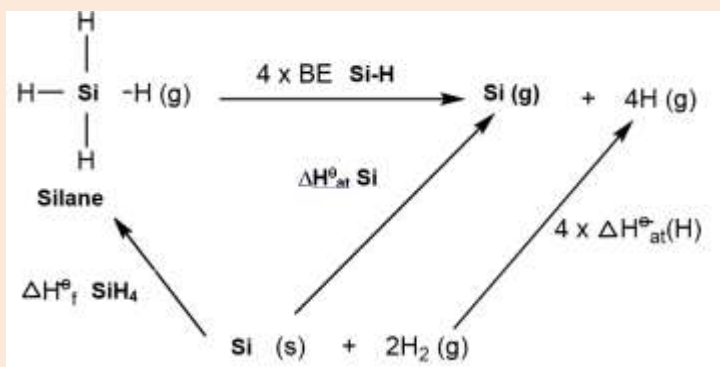
$$q = (25.0 + 25.0)(4.2)(2.5) = 525 \text{ J}$$

$$\Delta H = -(525)/(0.00875)$$

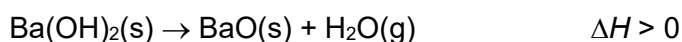
$$= -60 \text{ kJ mol}^{-1}$$

- 8 Silane, SiH_4 , exists as a gas at standard temperature and pressure. Hess' Law can be used to calculate the average Si–H bond energy in gaseous SiH_4 . Which information is needed to perform the calculation?
- A** $\Delta H^\circ_{\text{formation}}(\text{SiH}_4)$, $\Delta H^\circ_{\text{atomisation}}(\text{Si})$, $\Delta H^\circ_{\text{combustion}}(\text{H}_2)$
- B** $\Delta H^\circ_{\text{atomisation}}(\text{Si})$, $\Delta H^\circ_{\text{atomisation}}(\text{H})$, $\Delta H^\circ_{\text{formation}}(\text{SiH}_4)$
- C** $\Delta H^\circ_{\text{atomisation}}(\text{H})$, $\Delta H^\circ_{\text{combustion}}(\text{Si})$, $\Delta H^\circ_{\text{combustion}}(\text{SiH}_4)$
- D** $\Delta H^\circ_{\text{combustion}}(\text{Si})$, $\Delta H^\circ_{\text{combustion}}(\text{H}_2)$, $\Delta H^\circ_{\text{formation}}(\text{SiH}_4)$

Ans: B



- 9 Group 2 hydroxides undergo thermal decomposition in a similar fashion to Group 2 carbonates. Barium hydroxide undergoes decomposition as shown in the equation below:



Which statements about this reaction are correct?

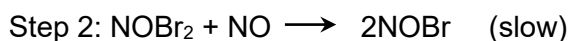
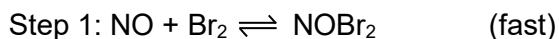
- 1 The Gibbs free energy change can be positive or negative depending on the temperature.
- 2 The decomposition is spontaneous only at high temperature.
- 3 The entropy change is negative.

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

Ans: A

ΔS is expected to be positive since there is formation of gaseous H_2O , thus statement 3 is wrong. ΔG can be positive or negative depending on the temperature. For reactions to be spontaneous, ΔG needs to be negative. As $\Delta G = \Delta H - T\Delta S$, T has to be high so that $|T\Delta S| > \Delta H$. Thus statement 2 is correct.

10 The reaction between NO and Br₂ is proposed to proceed via the following mechanism:



Which statements are correct?

- 1 NOBr₂ is a radical.
- 2 The rate equation for this reaction is $\text{rate} = k[\text{Br}_2][\text{NO}]^2$.
- 3 NOBr₂ is formed at the transition state.

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

Ans: B

Statement 1: Correct. There is one unpaired electron on the N atom in the molecule.

Statement 2: Correct.

From the slow step,

$$\text{Rate} = k[\text{NOBr}_2][\text{NO}] \text{ --- (1)}$$

From step 1, rate of forward reaction = rate of reverse reaction

$$k_f[\text{NO}][\text{Br}_2] = k_r[\text{NOBr}_2]$$

$$\frac{k_f}{k_r} = \frac{[\text{NOBr}_2]}{[\text{NO}][\text{Br}_2]}$$

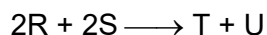
$$K_c = \frac{[\text{NOBr}_2]}{[\text{NO}][\text{Br}_2]}$$

$$[\text{NOBr}_2] = K_c[\text{NO}][\text{Br}_2] \text{ --- (2)}$$

$$\begin{aligned} \text{Sub. (2) into (1), Rate} &= k(K_c[\text{NO}][\text{Br}_2])[\text{NO}] \\ &= k'[\text{NO}]^2[\text{Br}_2] \end{aligned}$$

Statement 3: Incorrect. NOBr₂ is an intermediate as it appears in the reaction mechanism but does not appear in the overall equation.

- 11 The kinetics of the following reaction is investigated, and the experimental data is given in the table below.



[R] / mol dm ⁻³	[S] / mol dm ⁻³	initial rate / mol dm ⁻³ s ⁻¹
0.015	0.010	5.10×10^{-4}
0.030	0.020	4.08×10^{-3}
0.045	0.010	1.53×10^{-3}

What is the numerical value of the rate constant for this reaction?

A 0.00294

B 3.40

C 227

D 340

Ans: D

Comparing the first and third experiments,

When [R] $\times 3$ while keeping [S] constant, initial rate $\times 3 \Rightarrow \text{rate} \propto [\text{R}]$.

Hence, order of reaction with respect to R is 1.

Comparing the first and second experiments,

When [R] $\times 2$ and [S] $\times 2$, initial rate $\times 8$.

Since the order of reaction with respect to R is 1, rate $\propto [\text{S}]^2$.

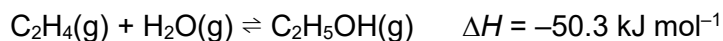
Hence, order of reaction with respect to S is 2.

The rate equation is: rate = $k[\text{R}][\text{S}]^2$

Using data from the first experiment,

$$k = 5.10 \times 10^{-4} \div (0.015 \times 0.010^2) = \underline{340} \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$$

- 12 Ethanol is produced industrially by reacting ethene and steam.



K_p has a value of 1.8×10^{-5} and the partial pressures of the reactants at equilibrium are shown.

reactant	partial pressure / $\times 10^6 \text{ Pa}$
ethene	4.8
steam	2.8

Which statement is correct?

- A Adding a catalyst increases the value of K_p for the reaction at equilibrium.
- B The overall process is a nucleophilic addition reaction.
- C Increasing the temperature will increase the K_p for the reaction.
- D Partial pressure of ethanol at equilibrium is $242 \times 10^6 \text{ Pa}$.

Ans: D

A is incorrect as K_p is only dependent on temperature.

B is incorrect, as the overall process is an electrophilic addition reaction.

C is incorrect. Increasing the temperature will result in POE shifting left favoring the endothermic reaction. Thus, K_p will decrease.

D is correct.

$$K_p = \frac{P_{\text{C}_2\text{H}_5\text{OH}}}{P_{\text{C}_2\text{H}_4} P_{\text{H}_2\text{O}}}$$

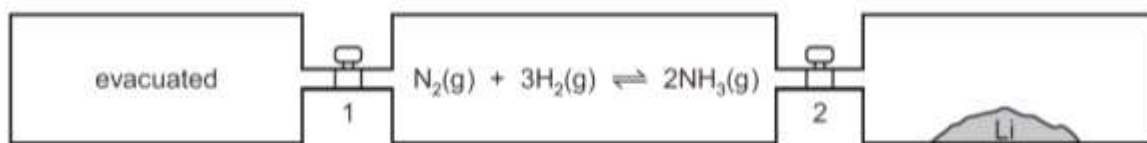
$$1.8 \times 10^{-5} = \frac{P_{\text{C}_2\text{H}_5\text{OH}}}{4.8 \times 10^6 (2.8 \times 10^6)}$$

$$P_{\text{C}_2\text{H}_5\text{OH}} = 242 \times 10^6 \text{ Pa}$$

Exam tips: If you know your content knowledge, you will know that A, B and C are wrong and D must be correct. There is no need to perform the calculation

- 13 Lithium reacts with nitrogen at room temperature to form solid Li_3N .

Three vessels of equal volume are connected by taps 1 and 2 as shown.



At the start, taps 1 and 2 are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

Which action would allow the equilibrium mixture to contain the **most** ammonia?

- A Keep both taps 1 and 2 closed.
- B Open both taps 1 and 2.
- C Open tap 1 only.
- D Open tap 2 only.

Ans: A

Tap 2 must be closed as $\text{N}_2(\text{g})$ can react with Li. This will cause the equilibrium position to shift left resulting in lower yield of $\text{NH}_3(\text{g})$.

Tap 1 must be closed. This is because if tap 1 is open, the total pressure will decrease and the equilibrium position will shift left to the side with more moles of gas particles resulting in lower yield of ammonia

- 14 The table below describes some indicators.

indicator	colour in acid	colour in alkali	pK_a	range of pH for colour change
methyl orange	red	yellow	3.7	3.2 – 4.4
thymol blue	yellow	blue	8.9	8.0 – 9.6

For the titration of NaOH(aq) against HCOOH(aq), which row shows the most suitable indicator and the corresponding colour change?

- | | indicator | colour change |
|---|---------------|------------------|
| A | methyl orange | red to orange |
| B | methyl orange | yellow to orange |
| C | thymol blue | yellow to green |
| D | thymol blue | blue to green |

Ans: D

The titration is between a strong base and weak acid. Hence the equivalence point $pH > 7$ as a basic salt is produced. Thymol blue will be a suitable indicator.
Since NaOH(aq) is in the conical flask, thymol blue will turn from blue to green.

- 15 In this question, Q represents an atom of chlorine, bromine or iodine.

Which statement about their atoms, molecules or halide ions is correct?

- A Down the Group, permanent dipole–permanent dipole forces between halogen molecules become stronger.
- B The first ionisation energy $Q(g) \rightarrow Q^+(g) + e^-$ decreases.
- C Q_2 reactivity as oxidising agent increases down the group.
- D The enthalpy change of formation of hydrogen halides becomes more exothermic.

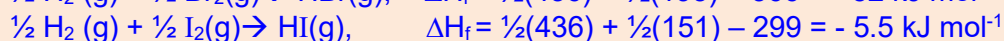
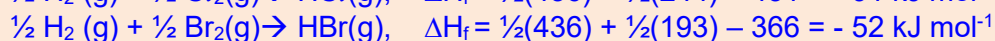
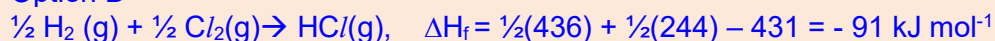
Ans: B

Option A should be: Down the Group, instantaneous dipole–induced dipole forces between halogen molecules become stronger.

Option B is correct: The first ionisation energy $Q(g) \rightarrow Q^+(g) + e^-$ decreases. By referring to Data Booklet: First IE are Cl: 1260 kJ mol⁻¹ Br: 1140 kJ mol⁻¹ I: 1010 kJ mol⁻¹

Option C is incorrect as Q_2 oxidising strength decreases down the group.

Option D



The enthalpy change of formation of hydrogen halides becomes more endothermic not exothermic

- 16 Magnesium, aluminium, silicon and phosphorus are consecutive elements in Period 3 of the Periodic Table.

Which of the following properties generally decreases from magnesium to phosphorus?

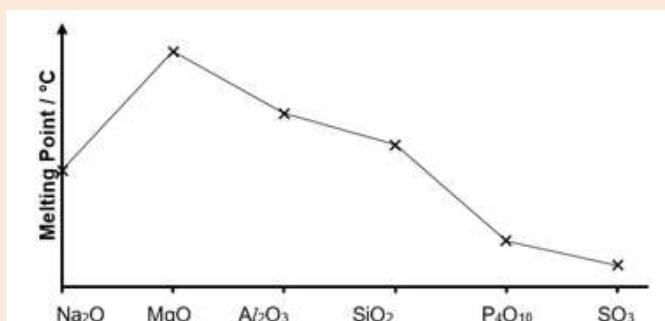
- A electrical conductivity
- B ionic radius
- C melting point of their oxides
- D electronegativity

Ans: C

Electrical conductivity increases from Mg to Al due to more delocalised electrons in Al in its sea of delocalised electron. Hence incorrect.

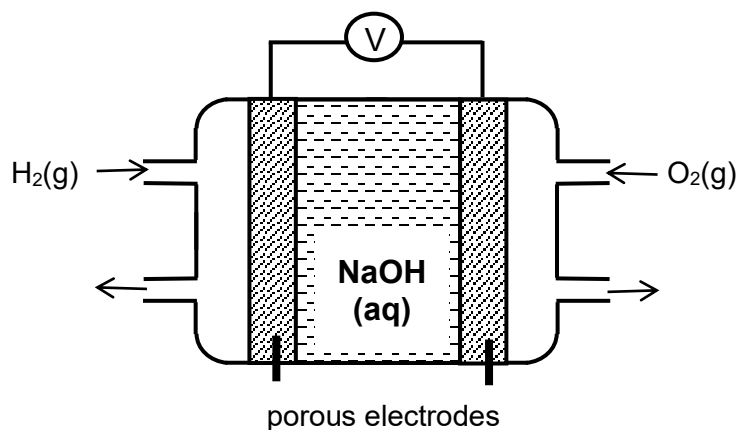
The ionic radius of P, being an anion, is larger than the other 3 which are cations. Hence incorrect. (You can check them out from the *Data Booklet*).

Their structure of their oxides transit from ionic (for Mg) to ionic with covalent character (for Al) to giant covalent (for Si) to simple covalent (for P). Hence their melting point decreases and correct.



Electronegativity increases across the Period.

- 17 A hydrogen-oxygen fuel cell is constructed using 1.00 mol dm^{-3} sodium hydroxide as the electrolyte. What is the change in pH of the solution around each electrode when the current is flowing?

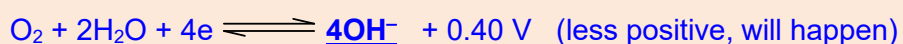
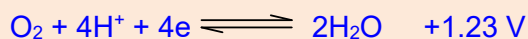


	Cathode	Anode
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

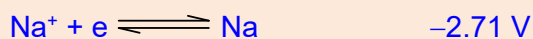
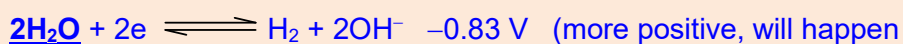
Ans: B

Half equations from *Data Booklet for analysis*

Anode (anion will migrate towards anode, H_2O is present as well)



Cathode (Cation will migrate towards cathode, H_2O is present as well)



At cathode, H_2O will undergo reduction to OH^- . Thus, $[\text{OH}^-]$ should increase resulting in increase in pH. (Note that Na^+ will not be reduced to Na at the cathode as the E° value is too negative.)

At anode, OH^- will undergo oxidation, this causes $[\text{OH}^-]$ to decrease and pH should decrease.

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

In the electrolysis of molten aluminium oxide, 0.27 g of aluminium is liberated when 2904 coulombs of electricity is passed through molten aluminium oxide.

Which value of Avogadro's constant do **these figures** give?

- A 6.02×10^{23}
- B 6.05×10^{23}
- C 1.82×10^{24}
- D 2.02×10^{23}

Ans: B

The **Avogadro's number (L) is the number of particles in one mole.**

In this question, it would be the number of electrons present in 1 mole of electrons.

1 Faraday (F) is the charge on 1 mole of electrons.

1 Faraday (F) = Avogadro's number (L) \times Charge on 1 e^- (e)

In this question, since we must solve for the Avogadro's number, we cannot use 1 Faraday as 96500 C mol^{-1} (which is obtained when we take Avogadro's number to be 6.02×10^{23}).

How to solve:

$$n(\text{Al}) = 0.27 \text{ g} \div 27.0 = 0.01 \text{ mol}$$

$$n(e^-) \text{ required to deposit 1 mol of Al} = 0.01 \times 3 = 0.03 \text{ mol}$$

Using $Q = n_e F$,

$$F = Q \div n_e = 2904 \div 0.03 = 96800$$

$$F = L \times e$$

Taking the value of e from the *Data Booklet*,

$$96800 = L \times 1.60 \times 10^{-19}$$

$$L = \underline{6.05 \times 10^{23}}$$

OR

Use the following 2 formulas:

$$\text{Amt} = \frac{I \times t}{n \times F} \quad \text{and} \quad F = L \times e$$

Substitute F into the first formula and since $Q = I \times t$ we have

$$\text{Amt} = \frac{Q}{n \times L \times e}$$

$$\frac{\text{mass}}{M_R} = \frac{Q}{n \times L \times e}$$

$$\frac{0.27}{27.0} = \frac{2904}{3 \times L \times 1.60 \times 10^{-19}} \quad (n = 3, \text{ since } \text{Al}^{3+} + 3e^- \rightarrow \text{Al}, \text{ hence 3 Faradays is required})$$

$$\text{Solving, } L = 6.05 \times 10^{23}$$

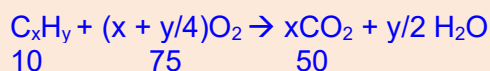
- 19 10 cm³ of an organic substance Z burns completely with exactly 75 cm³ of oxygen to produce 50 cm³ of carbon dioxide. All the volume are measured at the same temperature and pressure.

Which statements about the organic substance are correct?

- 1 Z may be an alcohol.
 - 2 Z may be cycloalkane.
 - 3 Z may decolorise aqueous bromine in the dark
- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 3 only

Ans: A

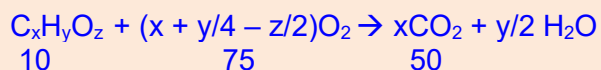
If X is a hydrocarbon,



$$x = 5, y = 10$$

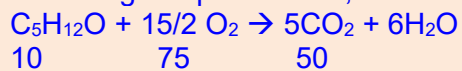
Z can be alkene which can decolourise bromine in the dark and it can also be cycloalkane.

If X is an alcohol



$$x = 5$$

assuming x is pentan-1-ol,

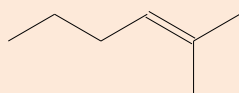


Thus, Z can be alcohol.

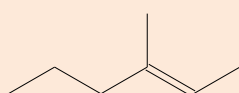
20 Which compound has the greatest number of stereoisomers?

- A 2-methylhex-2-ene
- B 3-methylhex-2-ene
- C 4-methylhex-2-ene
- D 5-methylhex-2-ene

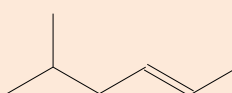
Ans: C



(2-methylhex-2-ene) do not exhibit stereoisomerism

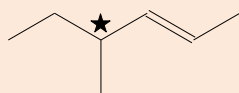


(3-methylhex-2-ene) and



(5-methylhex-2-ene)

These alkenes have only cis and trans isomers, number of stereoisomers = 2^1



4-methylhex-2-ene has $2^2 = 4$ stereoisomers

21 Which statement about methylbenzene and its properties is correct?

- A Methylbenzene undergoes nucleophilic substitution and free radical substitution reactions with Br_2 in the presence of AlBr_3 .
- B The methylbenzene molecule is planar so hydrogen can easily undergo addition reactions with it without the use of a catalyst.
- C The π electrons in the benzene ring are able to donate an electron pair to attack a carbocation to form a bond.
- D The sideways overlap of p orbitals in benzene means the C–C bonds alternate between long, single bonds and short, double bonds.

Ans: C

Statement A is incorrect.

Methylbenzene undergoes electrophilic substitution reactions in the presence of AlBr_3 and Br_2 . AlBr_3 being a Lewis acid will generate a Br^+ electrophile which will attack the benzene ring.

Statement B is incorrect.

Methylbenzene is resistant to addition reactions as it will destroy the extra stability brought about by the delocalisation of the π electrons in the benzene ring. Hydrogenation of benzene to cyclohexane, for example, requires a catalyst and high pressures. Methylbenzene is not a planar structure.

Statement C is correct.

The π electrons in benzene can donate an electron pair to attack a carbocation and form a bond. An example of this is when benzene donates its electron pair to CH_3^+ during a Friedel-Crafts alkylation reaction.

Statement D is incorrect.

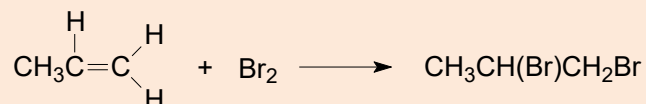
The sideways overlap of p orbitals in benzene means the C–C bonds in benzene are of equal length, and they do not alternate between single and double bonds; instead, they have an intermediate C–C partial double bond character.

22 Which pair of reagents react together in a redox reaction?

- A** $\text{CH}_3\text{CHCH}_2 + \text{Br}_2$
B $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + \text{concentrated H}_3\text{PO}_4$
C $\text{CH}_3\text{COCH}_3 + \text{HCN}$
D $\text{HCO}_2\text{C}_2\text{H}_5 + \text{dilute H}_2\text{SO}_4$

Ans: A

Option A:



Oxidation number of carbon: -3 -1 -2 -3 0 -1

Thus, oxidation number of carbon change from -1 to 0 and -2 to -1.

Oxidation number of bromine changes from 0 in Br_2 to -1 in $\text{CH}_3\text{CH}(\text{Br})\text{CH}_2\text{Br}$.

Option B:



Oxidation number of carbon: -3 -2 -1 -3 -1 -2

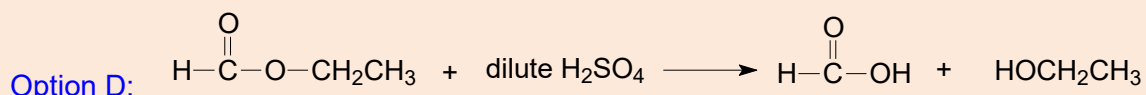
There is no change in oxidation number of the carbon, hydrogen and oxygen.



Option C:

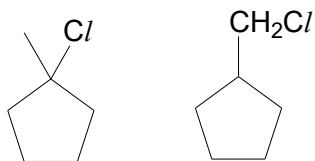
Oxidation number of carbon: 3 +2 -3 +2 -3 +2 -3

There is no change in oxidation number of the carbon, hydrogen, oxygen and nitrogen.

[illegible]

There is no change in oxidation number of the carbon, hydrogen and oxygen.

- 23 Methylcyclopentane can react with chlorine via free radical substitution to produce A and B as shown below.



A

B

Given the relative rate of substitution of tertiary and primary hydrogen atoms follows a 5 : 1 ratio.

What is the likely ratio of compound A and B formed?

- A** 1 : 15
B 1 : 3
C 3 : 5
D 5 : 3

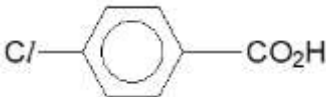
Ans: D

1 H each with reactivity of 5 $= 1 \times 5 = 5$	3 H each with reactivity of 1 $= 3 \times 1 = 3$

24 K_a values for two acids are given.

acid	K_a
$\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$	1.34×10^{-5}
$\text{C}_6\text{H}_5\text{CO}_2\text{H}$	6.46×10^{-5}

Which statement is correct?

- A** The K_a of $\text{CH}_3\text{C}_6\text{H}_4\text{OH}$ is larger than 1.34×10^{-5} .
- B** The K_a of $\text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H}$ is larger than 1.34×10^{-5} , but smaller than the K_a of $\text{CH}_2(\text{Cl})\text{CH}_2\text{CO}_2\text{H}$.
- C** In a mixture containing equal concentrations of $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and $\text{C}_6\text{H}_5\text{CO}_2\text{H}$, $[\text{CH}_3\text{CH}_2\text{CO}_2^-] = [\text{C}_6\text{H}_5\text{CO}_2^-]$.
- D** In two separate solutions of  and $\text{C}_6\text{H}_5\text{CO}_2\text{H}$, which have the same pH, there is a greater concentration of $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ in mol dm^{-3} .

Ans: D

Statement A is incorrect.

Methyl-phenol is less acidic than carboxylic acids thus the K_a is smaller.

Statement B is incorrect.

The presence of more electron-withdrawing Cl atom disperses the negative charge on anion $\text{CH}_3\text{CH}(\text{Cl})\text{CO}_2^-$ and stabilises it. Hence, $\text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H}$ is more acidic than $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and has a larger K_a value. When compared with $\text{CH}_2(\text{Cl})\text{CH}_2\text{CO}_2\text{H}$, $\text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H}$ will have a larger K_a (not smaller K_a as stated in the statement) as the Cl group is closer to the negative charge on anion $\text{CH}_3\text{CH}(\text{Cl})\text{CO}_2^-$.

Statement C is incorrect.

Since $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ has a lower K_a value, it is less acidic than $\text{C}_6\text{H}_5\text{COOH}$. Thus, at equal concentration of acids, $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ will dissociate to a lesser extent.

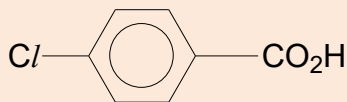
Statement D is correct.

The presence of electron-withdrawing Cl atom disperses the negative charge on conjugate base of 4-chlorobenzoic acid and stabilises it. Hence, 4-chlorobenzoic acid is more acidic than $\text{C}_6\text{H}_5\text{COOH}$ and able to dissociate to a greater extent to produce more H^+ ions.

$$\text{using } [\text{H}^+] = \sqrt{K_a \times [\text{acid}]}$$

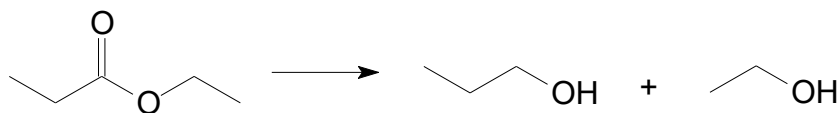
$$[\text{acid}] = \frac{[\text{H}^+]^2}{K_a}$$

when pH are similar, $[\text{H}^+]$ is the same, thus stronger the acid, greater K_a , the lower the $[\text{acid}]$

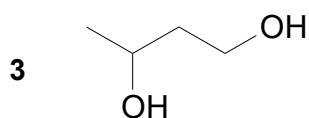
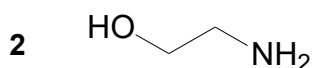
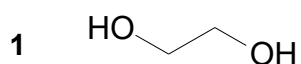
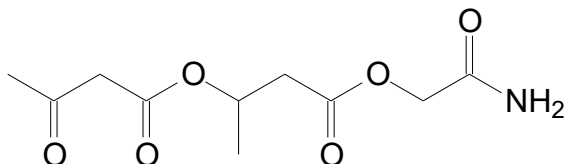


since $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ is a weaker acid than , concentration of $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ will be greater.

25 Esters can be reduced by LiAlH_4 in dry ether to give two alcohols as shown below.



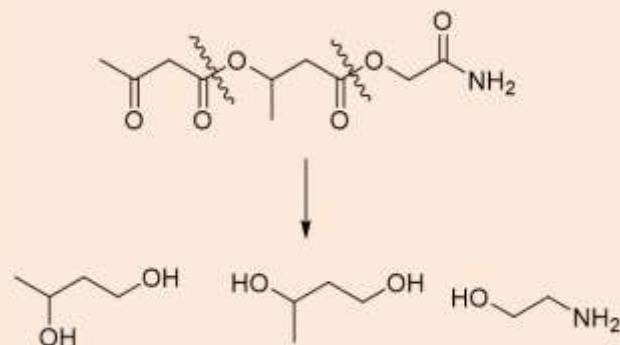
What are the possible products formed when the following compound is reacted with LiAlH_4 in dry ether?



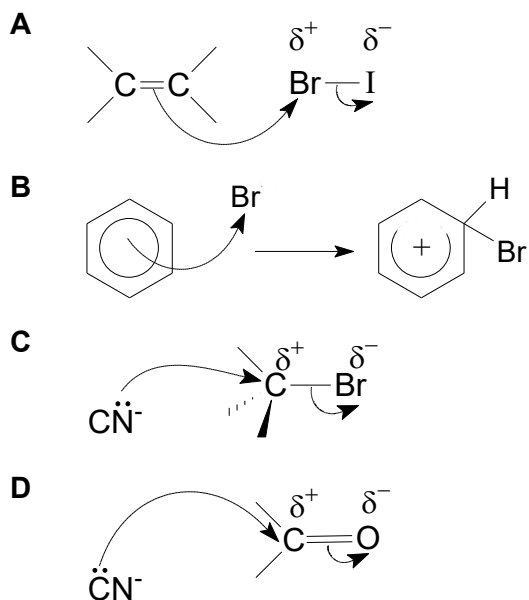
- A** 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

Ans: C

Apply the same pattern of reduction across the ester bonds to alcohols, bearing in mind that ketones are also reduced to secondary alcohols and amides are reduced to amines. Hence a total of three fragments are produced after the reaction.



26 Which of the following shows the most likely first step in the mechanism of a reaction?



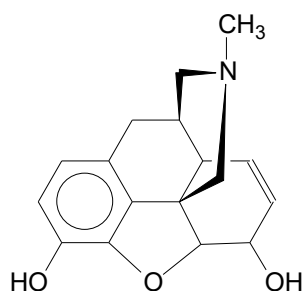
Ans: D

Option A is incorrect as bromine is more electronegative than iodine.

Option B is incorrect. Br^+ electrophile is required.

Option C is incorrect. Lone pair of electrons should be on C and not N. No doubt CN^- is an ambident nucleophile, it is not a likely step as N is more electronegative than C and thus will not share its electrons in a covalent bond. The C being less electronegative than C will share its electrons with the carbon in $\text{C}=\text{O}$ to form a covalent bond.

27 Morphine and codeine are both effective painkillers.



morphine

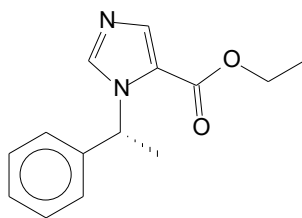
Which observation will be given by morphine?

- 1 the decolourisation of liquid bromine
 - 2 the evolution of hydrogen with metallic sodium
 - 3 the formation of green Cr^{3+} ions from an acidified solution of $\text{Cr}_2\text{O}_7^{2-}$
- A** 3 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

Ans: D

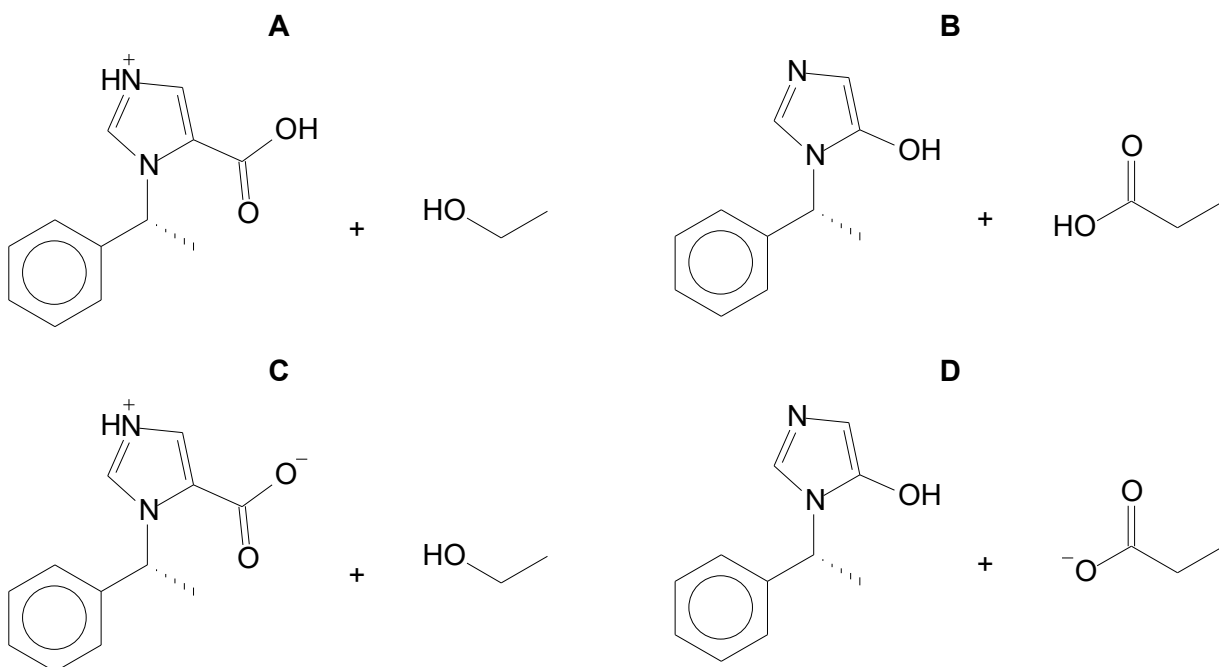
1. Presence of $\text{C}=\text{C}$, which decolourises orange $\text{Br}_2(\text{aq})$.
2. Presence of alcohol, which can react with $\text{Na}(\text{s})$ to produce $\text{H}_2(\text{g})$.
3. Presence of 2° alcohol, which can be oxidised by $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ (reduced to Cr^{3+})

- 28 Etomidate is an anaesthetic agent that has been found in e-vapourisers. It will soon be listed by Singapore as a Class C drug under the Misuse of Drugs Act.



etomidate

What are the products when etomidate is hydrolysed by heating with a dilute acid?



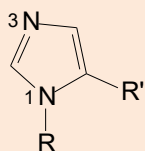
Ans: A

Etomidate contains an ester group (*hydrolysis*) and a basic nitrogen compound (*acid-base*) which will react with the dilute acid. Hydrolysis of the ester in etomidate gives ethanol (options **A** and **C**) and a carboxylic acid (option **A**) as products.

Teaching points for the acid-base reaction

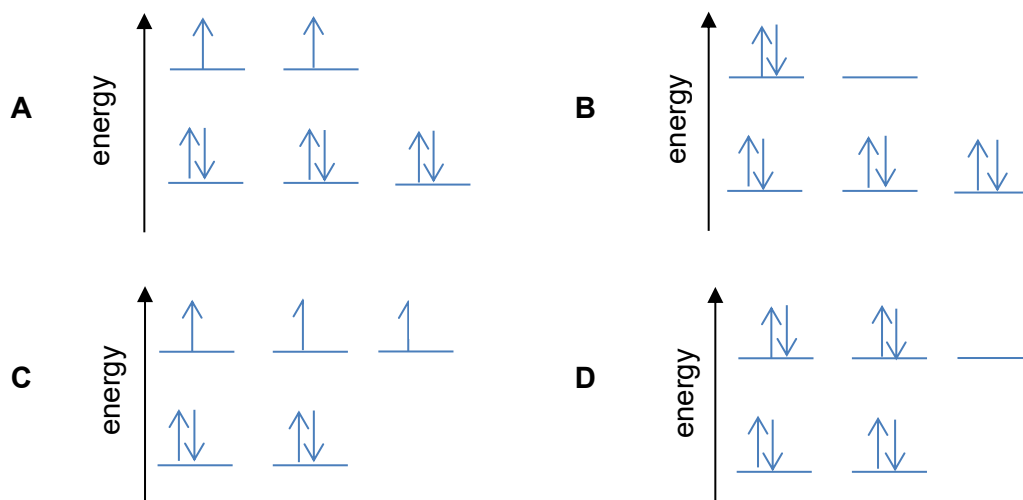
Etomidate contains two aromatic rings – phenyl group and substituted imidazole (a planar, 5-membered ring). Both N atoms in the imidazole ring are sp^2 hybridised; one of the N atoms is basic while the other is neutral.

Similar to how the lone pair on the N atom in a pyrrole molecule is delocalised (**N24/III/1c,d,e**), the lone pair in N1 forms part of the six π electrons in the aromatic ring and is not available in accepting a proton while the lone pair on N3 resides in a sp^2 hybrid orbital and is able to accept a proton. It is a weaker base than a sp^3 hybridised N atom though (sp^2 – more s-character and lone pair is closer to the nucleus and less available).



- 29 In a 'high spin' state, the electrons occupy all the d-orbitals singly, before starting to pair up in the lower energy d-orbitals.

Which energy diagram shows the electron arrangement in the 3d orbitals for a nickel in the +2 oxidation state in an octahedral complex in a 'high spin' state.

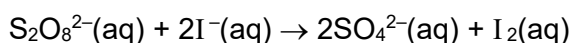


Ans: A

Ni^{2+} electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

Since it is an octahedral complex, the 3d orbital will split with 3 at the lower energy and 2 at the higher energy. Since high spin state is expected, electrons should occupy the d-orbital singly first before pairing up in the lower energy d-orbitals.

- 30 The rate of reaction between peroxodisulfate(VI) and iodide ions is increased by the presence of small concentrations of $\text{Fe}^{2+}(\text{aq})$.

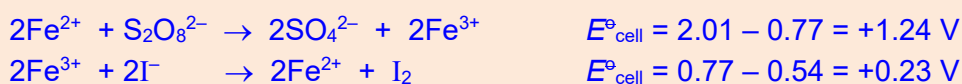


Which property of iron allows it to act as a homogeneous catalyst?

- A partially filled d subshell
- B variable oxidation states
- C low activation energy
- D high charge density

Ans: B

A homogeneous catalyst operates in the same phase as the reactants. Iron exhibits variable oxidation states which allows it to perform its role.



END