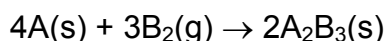


Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

- 1 A and B₂ react in the following way:



If A and B₂ are reacted together in a 2:1 mole ratio, what is the mole fraction of A₂B₃ upon complete reaction?

- A** 0.3 **B** 0.5 **C** 0.7 **D** 0.9

- 2 Naturally occurring iron consists of four isotopes, ⁵⁴Fe, ⁵⁶Fe, ⁵⁷Fe and ⁵⁸Fe. Two ions formed by the isotopes have chemical formulae shown below:



Which one of the following statements is true?

- A** The electron configuration of both Fe²⁺ ions is 1s²2s²2p⁶3s²3p⁶3d⁴4s².
B When subjected to an electric field, ⁵⁶/₂₆Fe²⁺ ion gives a greater angle of deflection than ⁵⁴/₂₆Fe²⁺ ion.
C ⁵⁶/₂₆Fe²⁺ ion has more protons in its nucleus than ⁵⁴/₂₆Fe²⁺ ion.
D The total number of protons and electrons in each of the Fe²⁺ ions is smaller than the nucleon number of the respective ion.

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

A gaseous mixture containing **m** g of N₂ and **n** g of CO₂ are injected into a completely evacuated container with fixed volume of 10⁻⁴ m³ at 25°C and 1 atm.

Assuming that the two gases do not react, which of the following gives the correct values for **m** and **n**?

	m	n
A	0.10	0.05
B	0.05	0.10
C	0.10	0.10
D	0.05	0.05

4 Which one of the following pairs contains two species with different shapes?

- A NCl_3 and BrCl_3
 B CO_3^{2-} and BBr_3
 C BeCl_2 and BrCl_2^-
 D SiF_4 and PF_4^+

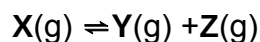
5 When 50 cm^3 of $1 \text{ mol dm}^{-3} \text{ NaOH(aq)}$ was added to 10 cm^3 of $1 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4\text{(aq)}$, a temperature rise of 5°C was obtained.

Assuming that there is negligible heat loss to the surroundings, what is the enthalpy change of neutralization?

(Density of solution may be taken as 1 g cm^{-3} and specific heat capacity of the solution as $4.2 \text{ J g}^{-1}\text{K}^{-1}$)

- A $-\frac{60 \times 4.2 \times 5 \times 1000}{10} \text{ kJ mol}^{-1}$ B $-\frac{60 \times 4.2 \times 5}{10} \text{ kJ mol}^{-1}$
 C $-\frac{60 \times 4.2 \times 5 \times 1000}{20} \text{ kJ mol}^{-1}$ D $-\frac{60 \times 4.2 \times 5}{20} \text{ kJ mol}^{-1}$

6 At 350°C , 50% of X decomposes according to the equation:

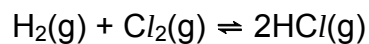


If the equilibrium pressure is $\frac{1}{3}p$, what is the equilibrium constant, K_p for the reaction at 350°C ?

- A $\frac{1}{9}p$ B $\frac{1}{6}p$ C $\frac{1}{3}p$ D p

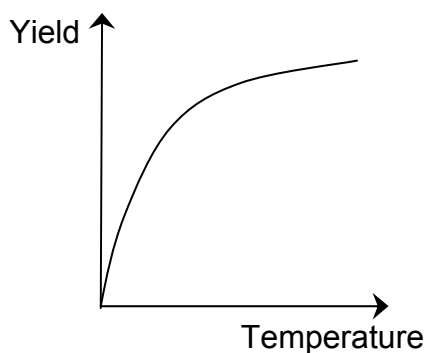
7 *Use of the Data Booklet is relevant to this question.*

Hydrogen chloride can be synthesized directly using a mixture of hydrogen gas and chlorine gas in a reversible reaction as shown:

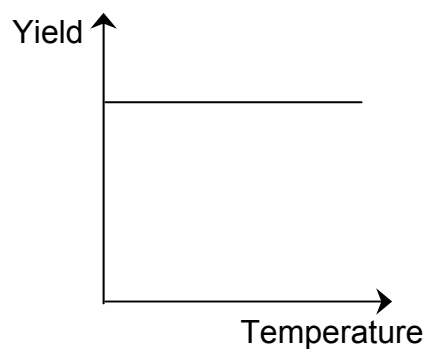


Which one of the following describes the yield of hydrogen chloride at equilibrium as temperature increases?

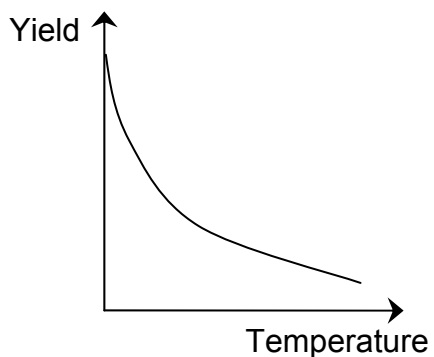
A



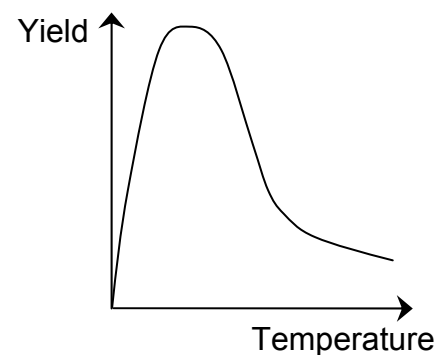
B



C



D



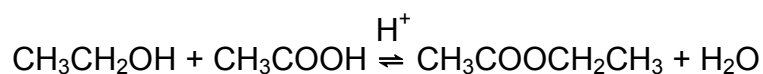
- 8 A $0.100 \text{ mol dm}^{-3}$ solution of lead(II) nitrate is added, with stirring, into an equal volume of a solution containing a mixture of Cl^- , Br^- , and I^- ions, each with the same concentration of $1.0 \times 10^{-2} \text{ mol dm}^{-3}$.

Given the following data:

Compound	Numerical value of solubility product (at 25°C)
Lead(II) chloride	1.7×10^{-5}
Lead(II) bromide	6.6×10^{-6}
Lead(II) iodide	9.8×10^{-9}

Which one of the following statements is correct?

- A No precipitate will form.
 B Only PbI_2 precipitate will form.
 C A mixture of PbI_2 and PbBr_2 precipitates will form.
 D All three precipitates, PbI_2 , PbBr_2 , and PbCl_2 , will form.
- 9 Ethyl ethanoate is formed by the reaction between ethanol and ethanoic acid as shown below:



Given that the above acid-catalyzed esterification is first order with respect to the hydrogen ion, and assuming that all other conditions are kept constant, what is the ratio $t_{\text{pH } 3} : t_{\text{pH } 1}$?

($t_{\text{pH } n}$ = time taken for the reaction conducted at $\text{pH} = n$ to achieve 80% yield)

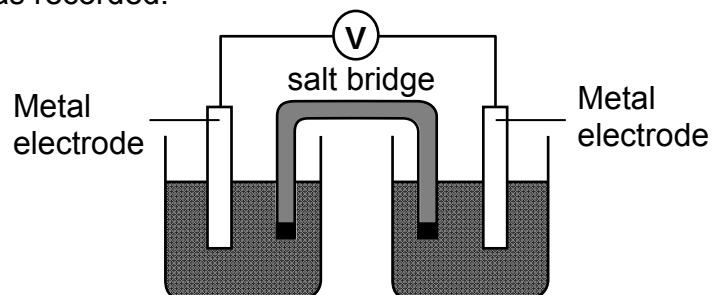
- A 0.01 B 0.33 C 3 D 100
- 10 Radioactive decay obeys first order kinetics. The amount of radioactivity recorded from an isotope decreased from 2720 units to 85 units in 45 hours.

What is the time required for the radioactivity of the same isotope to drop from 2400 units to 300 units?

- A 9 hours B 18 hours C 27 hours D 36 hours

11 Use of the Data Booklet is relevant to this question.

The half-cells of four metals Pb, X, Y and Z were connected in pairs and the voltage was recorded.



The results obtained are set out in the table below.

Negative electrode	Positive electrode	Voltage /V
Pb	X	0.35
Z	Pb	2.60
Y	Pb	1.10

Which one of the following statements is correct?

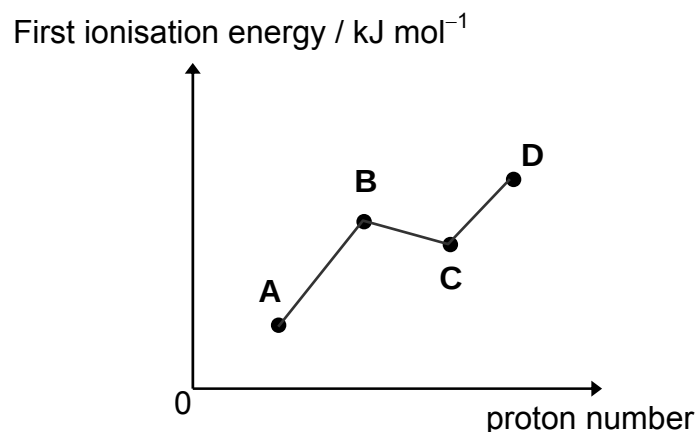
- A** Anions will flow from the salt bridge to the $X^{n+}_{(aq)} | X_{(s)}$ half-cell when it is connected to $Z^{p+}_{(aq)} | Z_{(s)}$ half-cell.
- B** Pb has a greater tendency than Y to form positively charged ions.
- C** The colour of aqueous $CuSO_4$ solution will become lighter when Y is added to it.
- D** Electrons will flow from electrode Y to electrode Z when the two half-cells of $Z^{p+}_{(aq)} | Z_{(s)}$ and $Y^{m+}_{(aq)} | Y_{(s)}$ are connected together.

12 Two electrolytic cells containing aqueous $X(NO_3)_m$ in cell 1 and molten YCl_n in cell 2 are connected in series. When a current was passed through the set-up, metals X and Y are produced at the cathode of cell 1 and cell 2 respectively. The volume of the gas produced at the anode of cell 1 and cell 2 is $p \text{ cm}^3$ and $q \text{ cm}^3$ respectively.

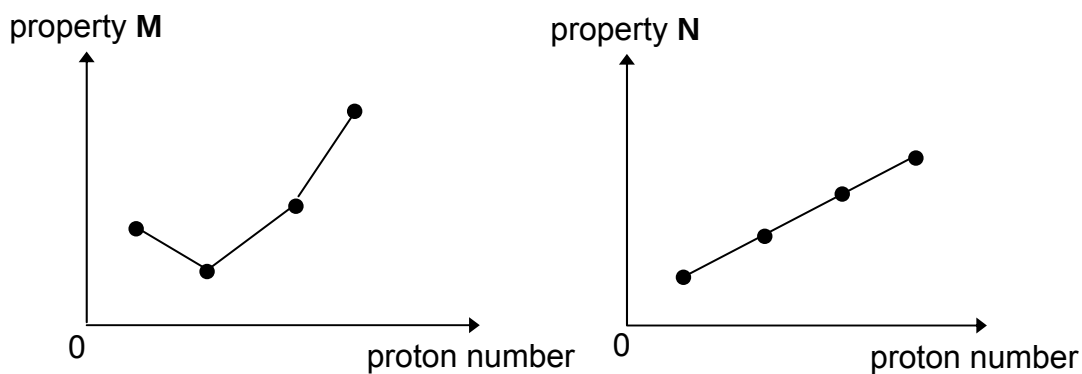
What is the ratio of $p : q$?

- A** 2:3
- B** 3:2
- C** 1:2
- D** 2:1

- 13** The diagram represents the first ionisation energy of four consecutive elements in the third period of the Periodic Table, with element **B** showing two oxidation states in its chlorides.



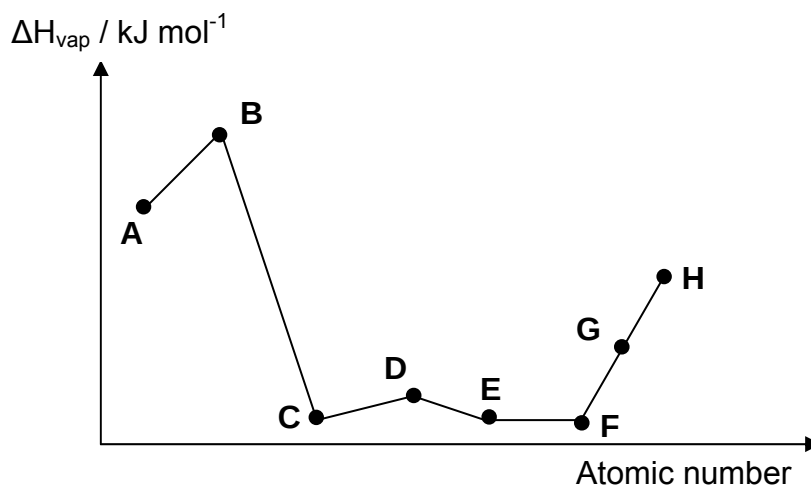
The sketches below represent another two properties of the elements.



What are properties **M** and **N**?

	property M	property N
A	third ionisation energy	electronegativity
B	number of valence electrons	boiling point
C	ionic radius	effective nuclear charge
D	electrical conductivity	atomic radius

- 14 The graph below shows the variation in the enthalpy change of vaporisation, ΔH_{vap} for 8 consecutive elements in the Periodic Table, all with atomic number ≤ 20 .



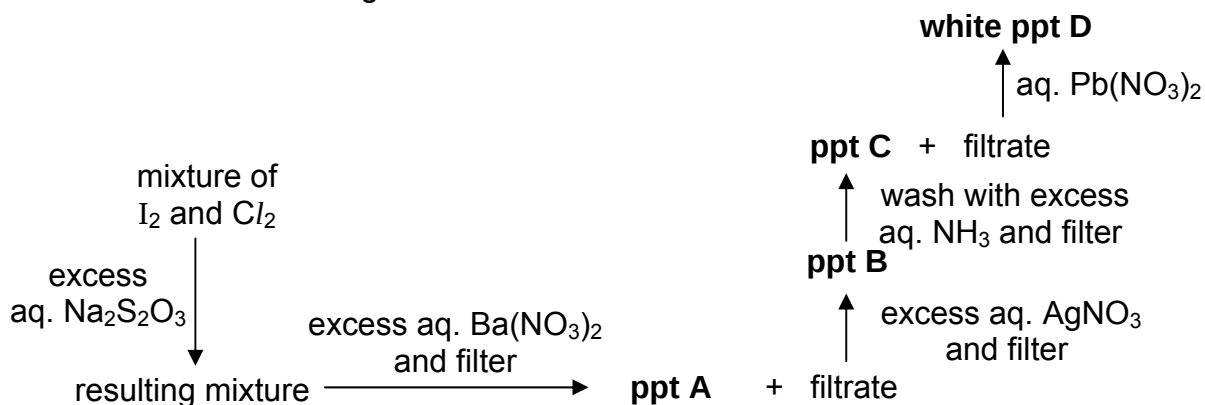
What can be deduced from the above graph?

- A E is soluble in warm benzene whereas F is not.
- B The chlorides become less acidic from A to C.
- C The pH of the solution containing a mixture of oxide of G and oxide of D is greater than 7.
- D The oxide of A reacts with excess aqueous sodium hydroxide to form a soluble complex.
- 15 Radium is the last element in Group II in the Periodic Table.

Which one of the following is **not** true for radium?

- A It is the least reactive element in Group II.
- B It reacts with water to release hydrogen gas.
- C Its oxide is basic in water.
- D Its compounds conduct electricity when molten.

16 Consider the following reaction route.



Which anion was present in each of the precipitates respectively?

	ppt A	ppt C	ppt D
A	I^-	SO_4^{2-}	NO_3^-
B	Cl^-	I^-	NO_3^-
C	SO_4^{2-}	I^-	Cl^-
D	SO_4^{2-}	NO_3^-	Cl^-

17 The table shows the electronic configuration of five d-block elements in the Periodic Table.

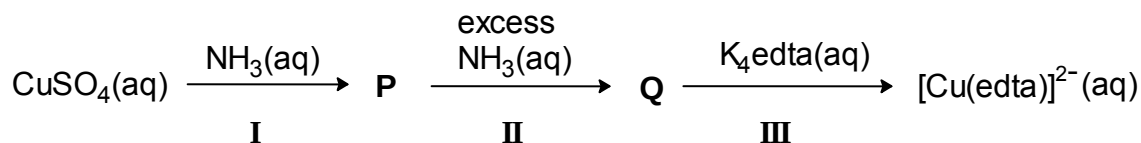
(The elements are represented by letters which are not their symbols.)

Element	Electronic configuration of the element
P	$[Ar]3d^24s^2$
Q	$[Ar]3d^54s^1$
R	$[Ar]3d^54s^2$
S	$[Ar]3d^64s^2$
T	$[Ar]3d^74s^2$

Which one of the following statements is **incorrect**?

- A $Q_2O_7^{2-}$ is likely to exist.
- B On reduction of the solution containing $[P(H_2O)_6]^{3+}$ to $[P(H_2O)_6]^{2+}$, the solution will turn colourless.
- C S^{2+} can be oxidized to S^{3+} by R^{3+} , which itself is reduced to R^{2+} .
- D The electronic configuration of $[T(H_2O)_6]^{3+}$ is $[Ar]3d^6$.

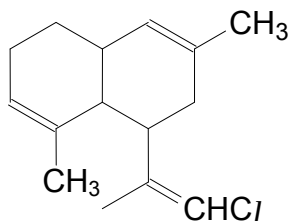
- 18 A reaction scheme starting from aqueous copper(II) sulfate solution is shown below. Both **P** and **Q** are copper-containing species.



where edta is $(\text{CH}_2\text{CO}_2^-)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2^-)_2$.

Which one of the following statements is **incorrect**?

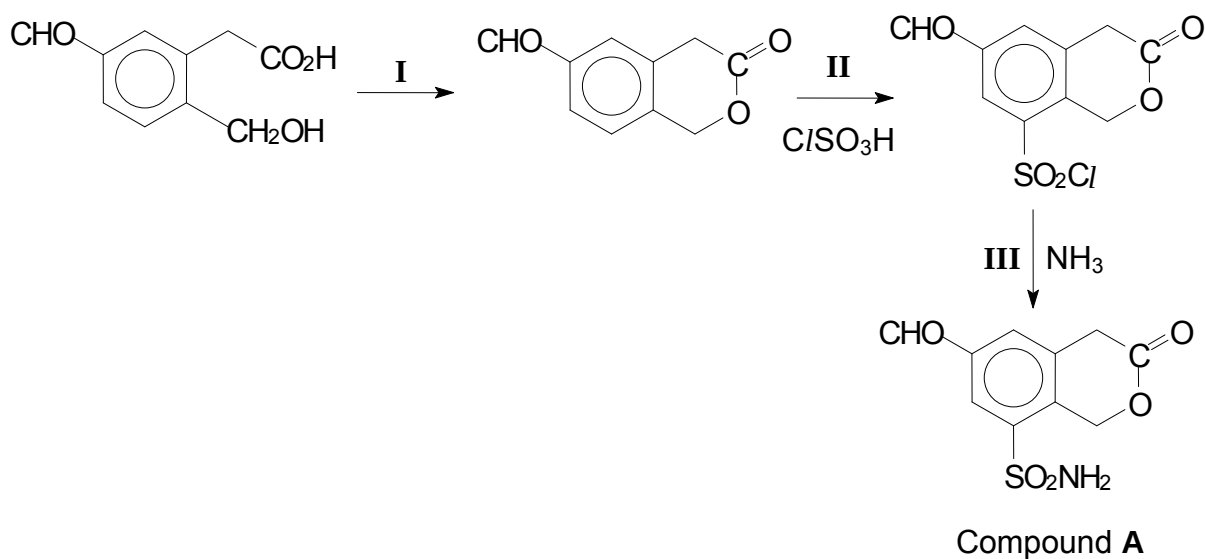
- A $[\text{Cu}(\text{edta})]^{2-}$ is an octahedral complex.
 B $[\text{Cu}(\text{edta})]^{2-}$ is a more stable complex than **Q**.
 C **Q** is a deep blue solution containing $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{SO}_4$.
 D NH_3 acts as a ligand in reaction I.
- 19 The following compound is a derivative of α -Cadinene which can be found in juniper berries.



What is the number of stereoisomers for the major product formed after the above compound has reacted with C/Br ?

- A 64
 B 128
 C 256
 D 512

20 Compound A is synthesised in a three-step synthesis below.



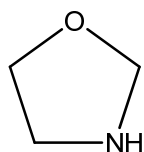
What type of reaction do steps I to III each illustrate?

	I	II	III
A	Condensation	Electrophilic substitution	Nucleophilic substitution
B	Condensation	Electrophilic substitution	Electrophilic substitution
C	Nucleophilic substitution	Nucleophilic substitution	Electrophilic substitution
D	Electrophilic substitution	Electrophilic substitution	Nucleophilic substitution

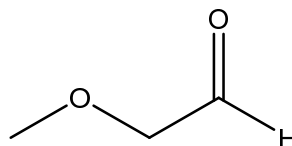
21 In which one of the following processes is at least one product a gas at room temperature and pressure?

- A oxidation of ethanal by acidified potassium dichromate(VI)
- B dehydration of ethanol
- C esterification of ethanoic acid by ethanol
- D substitution of ethanol by hydrogen bromide

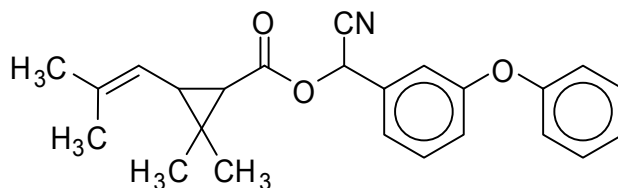
- 22 Which one of the following statements best accounts for the difference in the boiling points of oxazolidine and compound **W**?



Oxazolidine

Compound **W**

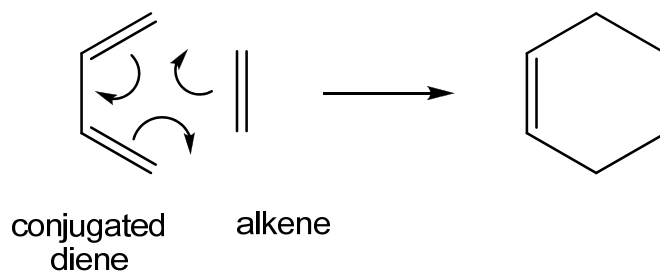
- A Oxazolidine is spherical, while **W** is linear.
 B Oxygen is more electronegative than nitrogen.
 C Oxazolidine has 3 lone pairs of electrons while **W** has 4 lone pairs of electrons.
 D Hydrogen bonding is stronger than dipole-dipole interactions.
- 23 *Cyphenothrin* is a pyrethrin insecticide which has strong contact and stomach poisoning activity, as well as good residual activity.

***Cyphenothrin***

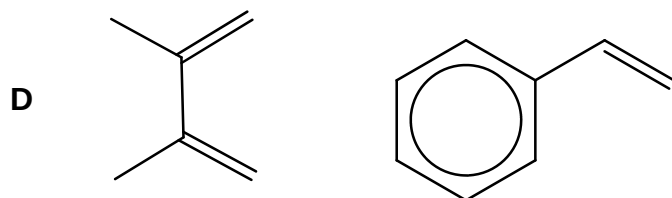
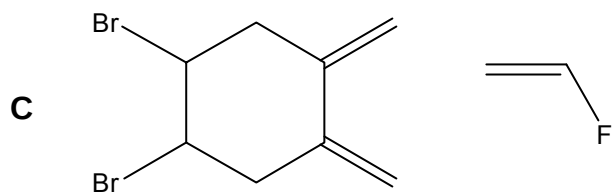
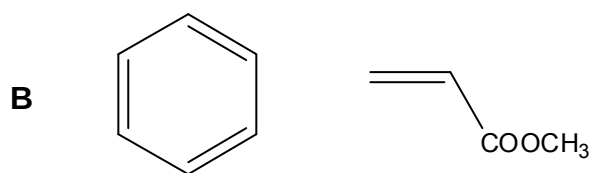
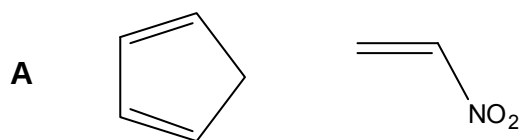
What are the organic products from the reaction of *cyphenothrin* with an excess of boiling aqueous NaOH?

- A
- B
- C
- D

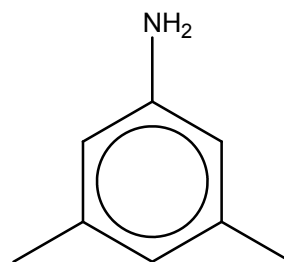
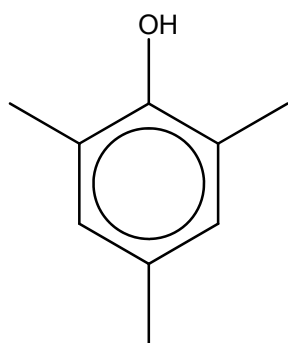
- 24 The Diels-Alder reaction is a cycloaddition between an electron-rich conjugated diene and an electron-poor alkene to form a cyclohexene ring.



Which one of the following pairs of compounds will undergo the Diels-Alder reaction at the fastest rate?



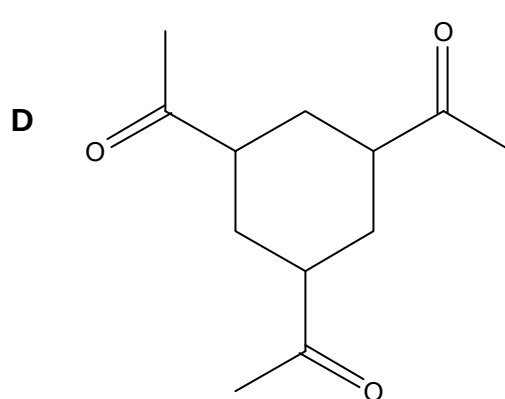
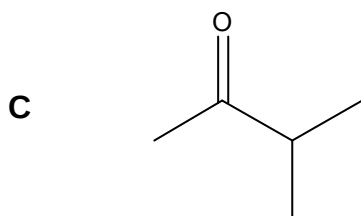
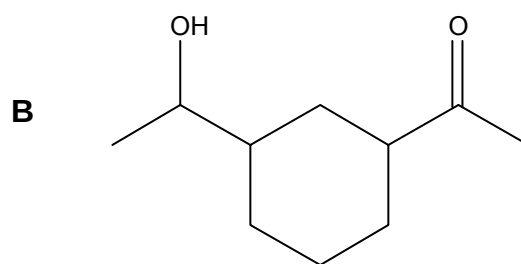
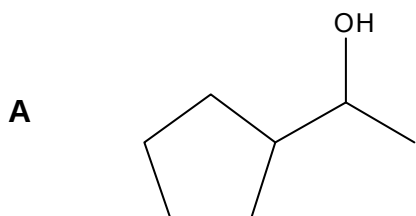
- 25 Four students suggested reagents that can differentiate the following two compounds.



Which suggested reagent is most suitable?

- | | | | |
|----------|------------------|----------|---------------------------|
| A | thionyl chloride | B | neutral iron(II) chloride |
| C | bromine water | D | sodium carbonate |
- 26 0.010 mol of an organic compound was warmed with excess alkaline iodine. The mixture was then filtered, and the filtrate was washed with tetrachloromethane to remove unreacted iodine. The aqueous layer was treated with a dilute acid, followed by aqueous silver nitrate, and 0.030 mol of yellow precipitate was collected.

Which one of the following is a possible structure of the organic compound?



- 27 Which one of the following shows the given ions arranged in order of increasing pK_a values?

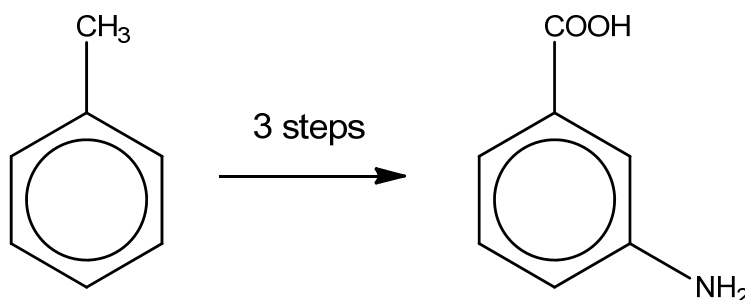
- A NH_4^+ , $\text{C}_6\text{H}_5\text{NH}_3^+$, $(\text{CH}_3\text{CH}_2)_2\text{NH}_2^+$
 B $\text{C}_6\text{H}_5\text{NH}_3^+$, NH_4^+ , $(\text{CH}_3\text{CH}_2)_2\text{NH}_2^+$
 C $(\text{CH}_3\text{CH}_2)_2\text{NH}_2^+$, $\text{C}_6\text{H}_5\text{NH}_3^+$, NH_4^+
 D $(\text{CH}_3\text{CH}_2)_2\text{NH}_2^+$, NH_4^+ , $\text{C}_6\text{H}_5\text{NH}_3^+$

- 28 A sample of bromoethane was warmed with ethanolic silver nitrate, and a cream precipitate was observed after about 4 minutes.

Under similar reaction conditions, which one of the following compounds will result in precipitate formation only after 8 minutes?

- A iodoethane
 B ethanoyl bromide
 C bromobenzene
 D chloroethane

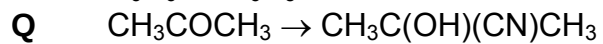
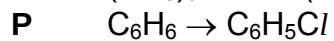
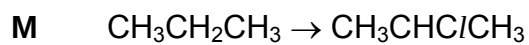
- 29 The following transformation takes place over a series of three steps.



Which one of the following shows the correct choice of reagents and conditions?

- | | Step I | Step II | Step III |
|---|---|---|--|
| A | Conc. HNO_3 , Conc. H_2SO_4 , 30°C | Heat with conc. HCl , Sn , followed by NaOH | Reflux with acidified KMnO_4 |
| B | Conc. HNO_3 , Conc. H_2SO_4 , 30°C | LiAlH_4 in dry ether, followed by hydrolysis | Reflux with acidified KMnO_4 |
| C | Reflux with acidified KMnO_4 | Conc. HNO_3 , Conc. H_2SO_4 , 60°C | Heat with conc. HCl , Sn , followed by NaOH |
| D | Reflux with acidified KMnO_4 | Conc. HNO_3 , Conc. H_2SO_4 , 60°C | LiAlH_4 in dry ether, followed by hydrolysis |

30 Which pair of reactions will occur via organic intermediates of the same charge?



A **M** and **N**

B **N** and **Q**

C **N** and **P**

D **P** and **Q**

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

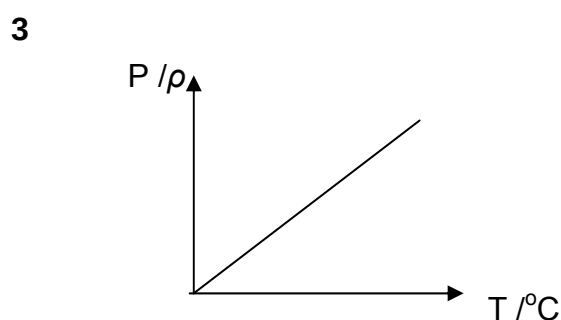
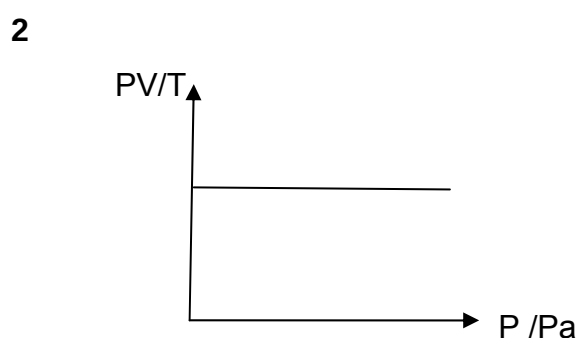
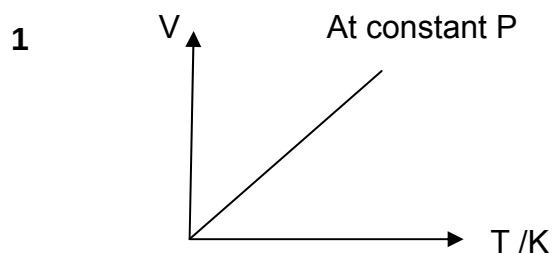
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 31** Which of the following diagrams correctly describes the behaviour of a fixed mass of an ideal gas?

(P = pressure, ρ = density, V = volume, T = temperature).



The responses **A** to **D** should be selected on the basis of

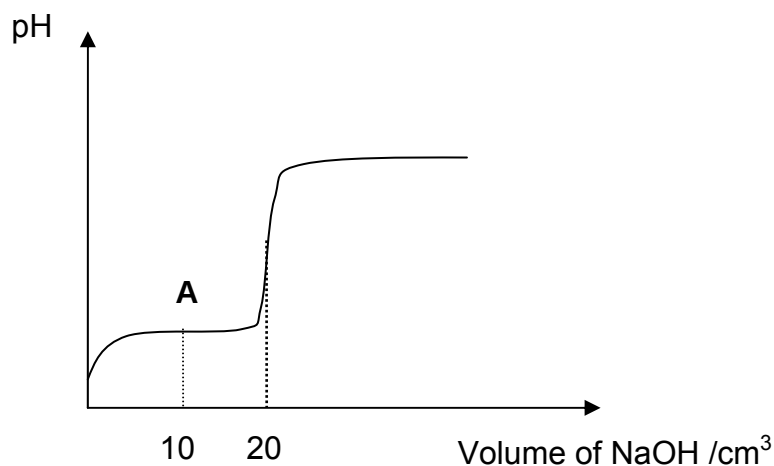
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

32 For which of the following pairs does the first species have a smaller bond angle?

- 1** XeF₄, SeF₂
- 2** CrO₄²⁻, SO₃²⁻
- 3** BH₃, AsH₃

33 10.0 cm³ of 0.100 mol dm⁻³ of an acid **X** is titrated against 0.0500 mol dm⁻³ of NaOH. The graph of pH against volume of NaOH added is shown:



Given that K_a of acid **X** is 1.4×10^{-3} mol dm⁻³, which of the following statements correctly describes the titration?

- 1** Acid **X** can be 2-bromoethanoic acid
- 2** The solution can withstand pH changes most effectively at point **A**.
- 3** The initial pH is 1.93.

- 34** Three substances, **X**, **Y** and **Z**, react to give a precipitate. The reaction mixture in a conical flask was placed on a piece of paper marked with a cross. The time taken, **t**, for various initial molar concentrations of **X**, **Y** and **Z** to produce enough precipitate to completely block the cross are given in the following table:

Experiment	[X]	[Y]	[Z]	<i>t</i> /s
1	0.5	0.05	0.05	120
2	2.0	0.05	0.05	120
3	1.0	0.10	0.05	30
4	1.0	0.10	0.10	15
5	1.5	0.05	0.10	?

Which statements can be deduced from these results?

- 1 The rate equation for the reaction is $\text{rate} = k [\text{Y}]^2 [\text{Z}]$
 - 2 The value of **t** for experiment 5 is 60 s.
 - 3 The units of the rate constant are $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$.
- 35** When acidified potassium iodide containing some starch is left to stand in the air, the solution gradually darkens and turns dark blue. The blue colour is discharged upon the addition of sufficient aqueous sodium hydroxide. When the resulting solution is heated to dryness, a white solid remains.

Which iodine containing anions are produced in the reactions above?

- 1 I^-
 - 2 IO^-
 - 3 IO_3^-
- 36** Experiment 1: Addition of aqueous ammonia to aqueous CuSO_4 causes a pale blue precipitate to form which dissolves in excess ammonia to give a deep-blue solution.

Experiment 2: Addition of aqueous potassium iodide to blue aqueous copper(II) sulfate produces a white precipitate and a brown solution.

What can be deduced from the experiments?

- 1 There is no redox reaction occurring for both experiments.
- 2 The pale blue precipitate dissolves in excess ammonia due to the formation of a complex ion in experiment 1.
- 3 The brown solution formed in experiment 2 is decolourised when aqueous sodium thiosulfate is added.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 37** A species of ants found in South Africa secretes compound **Z** below to warn fellow ants from the same colony of dangers.

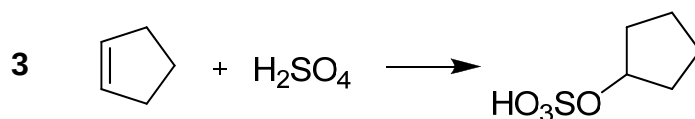
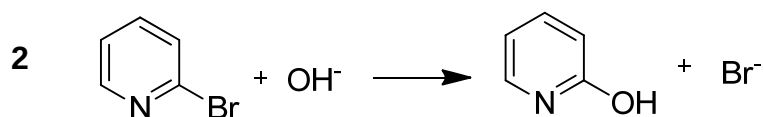
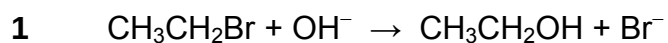


Z

Which of the following statements are true about compound **Z**?

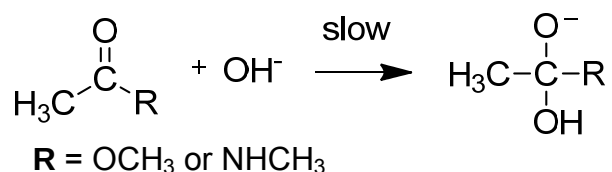
- 1** 5 mol of gas are obtained from 1 mol of **Z** when excess hot acidified potassium manganate(VII) is added.
- 2** **Z** does not form an orange precipitate with 2,4-dinitrophenylhydrazine.
- 3** **Z** turns hot acidified potassium dichromate(VI) from orange to green.

- 38** Which of the following reactions are examples of nucleophilic substitution?



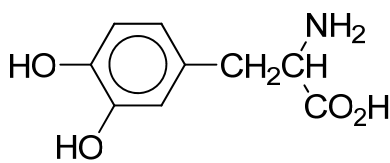
- 39** 1 mol of an ester ($\text{CH}_3\text{CO}_2\text{CH}_3$) and an amide ($\text{CH}_3\text{CONHCH}_3$) underwent base hydrolysis separately and the initial rate of reaction was measured. It was found that the ester undergoes hydrolysis approximately three times faster than the amide.

The slow step of the base hydrolysis of the ester and amide is the same and shown below.



Which statements help to explain the faster rate of base hydrolysis of the ester?

- 1** Oxygen is more electronegative than nitrogen.
 - 2** The lone pair of electrons on the nitrogen atom in the amide interacts with the carbonyl group.
 - 3** There are two lone pairs of electrons on the oxygen atom in the R group of ester and only one lone pair of electron on the nitrogen atom in the R group of amide.
- 40** Dopamine is a neurotransmitter. Its absence from the human brain might lead to Parkinson's disease.



Dopamine

Which statements about Dopamine are correct?

- 1** The pH of the solution of Dopamine will decrease when aqueous bromine is added.
- 2** It is soluble in water due to zwitterion formation.
- 3** It migrates to the anode of an electrolytic cell at pH 12.