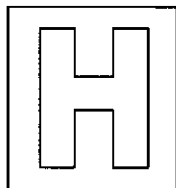


Class Adm No

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Candidate Name: _____



2024 Preliminary Examinations Pre-University 3

H2 CHEMISTRY

Paper 1 Multiple Choice

9729/01

18 Sep 2024

1 hour

Additional materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so.

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

At the top of this page:

Write your name, class and admission number in the spaces provided.

On the Answer Sheet:

Write your name, class and subject.

Write your identification number and shade the corresponding bubbles.

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.

FOR EXAMINER'S USE	
TOTAL (30 marks)	

This question paper consists of 12 printed pages and 2 blank pages.

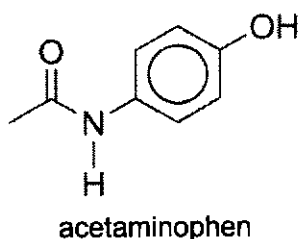
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Which of the following statements are correct about 1 mole of C(s)?

- 1 It contains 6.02×10^{23} carbon atoms.
- 2 It has a mass of 12.0 g.
- 3 It contains 12 moles of electrons.
- 4 It occupies a volume of 24.0 dm^3 at room temperature and pressure.

A 1 and 2 only **B** 3 and 4 only **C** 1, 2 and 3 only **D** 2, 3 and 4 only

2 A painkiller pill contains 500 mg of acetaminophen, $\text{C}_8\text{H}_9\text{NO}_2$.

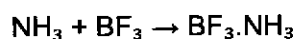


What is the mass of nitrogen present in one pill?

[1 g = 1000 mg]

A 0.046 g **B** 0.093 g **C** 0.151 g **D** 0.700 g

3 Ammonia reacts with boron trifluoride in the following equation.



What is the role of NH_3 in the reaction?

- A** Brønsted-Lowry acid
- B** Brønsted-Lowry base
- C** Lewis acid
- D** Lewis base

- 4 When excess potassium iodide, KI, is added to potassium iodate(V), iodine is produced.



Which of the following statements is **incorrect** about the reaction?

- A Iodine in IO_3^- was reduced.
 B Iodine in I^- was oxidised.
 C The reaction is a disproportionation reaction.
 D The oxidation number of iodine in I_2 is 0.
- 5 Which of the following statements is **not** true of an element in Period 3?
- A It has electrons in the spherically shaped orbitals.
 B It has three dumb-bell shaped orbitals in its outermost shell.
 C It has five orbitals with four lobes in each orbital.
 D It is able to accommodate more than 8 electrons in its outermost shell.
- 6 A beam of ${}_{11}^{23}\text{Na}^+$ ions were passed through an electric field and it was found to deflect by an angle of $+8.5^\circ$.

What is the angle of deflection for a beam of ${}_{15}^{31}\text{P}^{3-}$ ions travelling at the same speed through the same electric field?

- A -34.4° B -18.9° C -18.7° D -3.8°

- 7 Which of the following correctly describe the structure and bonding in carbon?

- 1 It contains strong C–C covalent bonds.
 2 It can contain weak instantaneous dipole-induced dipole forces of attraction.
 3 It can have a giant lattice structure.

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

- 8 An unknown element **J** exists as a liquid at 35 °C and is electrically conductive in both the solid and liquid states.

Another unknown element **K** exists as a gas at 35 °C and does not conduct electricity in both the solid and liquid states.

Which of the following statements are **false** about the compound formed between **J** and **K**?

- A It could conduct electricity in the molten state.
- B It could exist as non-polar molecules.
- C It could have the formula **JK₂**.
- D It could contain delocalised electrons.

- 9 Which of the following statements correctly describe ideal gas behaviour?

- A 1 mol of oxygen gas occupies 22.7 dm³ at room temperature and pressure.
- B 1.06 mol of carbon dioxide gas occupies 24.0 dm³ at standard temperature and pressure.
- C At low temperatures, nitrogen gas turns into a liquid.
- D At constant pressure, concentration of hydrogen gas increases when temperature increases.

- 10 In an isolated system, a 2.5 dm³ vessel containing neon gas at -43 °C and 80 kPa was connected to a 5.5 dm³ vessel containing helium gas at -97 °C and 39 kPa. The valve was opened and the gases were allowed to mix.

The final pressure of the mixture was found to be 59 kPa.

Assuming ideal gas behaviour, what is the final temperature of the mixture?

- A -18 °C B -47 °C C -70 °C D -116 °C

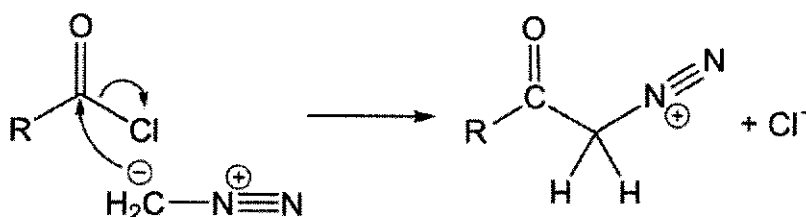
- 11 Which of the following equations represents the standard enthalpy change of atomisation of the species?

- A $\frac{1}{2}\text{Br}_2(\text{g}) \rightarrow \text{Br}(\text{g})$
- B $\text{Hg}(\text{l}) \rightarrow \text{Hg}(\text{g})$
- C $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
- D $\text{Na}(\text{s}) \rightarrow \text{Na}^+(\text{g})$

12 Which of the following statements help to explain why the enthalpy change of solution of sodium chloride is endothermic?

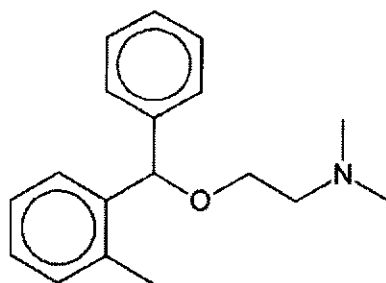
- A The lattice energy is more exothermic than the sum of the hydration energies of the ions.
- B The lattice energy is less exothermic than the sum of the hydration energies of the ions.
- C The energy released from the formation of ion-dipole interactions is sufficient to overcome the ionic bonds.
- D The energy released from the formation of ion-dipole interactions is insufficient to overcome the ionic bonds.

13 Consider the following reaction mechanism.



Which of the following statements about the reaction is **incorrect**?

- A CH_2N_2 acts as an electrophile.
 - B CH_2N_2 acts as a Lewis base.
 - C CH_2N_2 acts as a nucleophile.
 - D It is a substitution reaction.
- 14 Which of the following statements are true about orphenadrine?



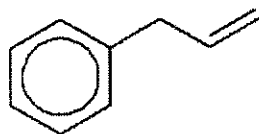
orphenadrine

- 1 It can exhibit enantiomerism.
- 2 It has a $\text{p}K_a$ that is greater than 7 at 25 °C.
- 3 It has the molecular formula $\text{C}_{16}\text{H}_{23}\text{NO}$.

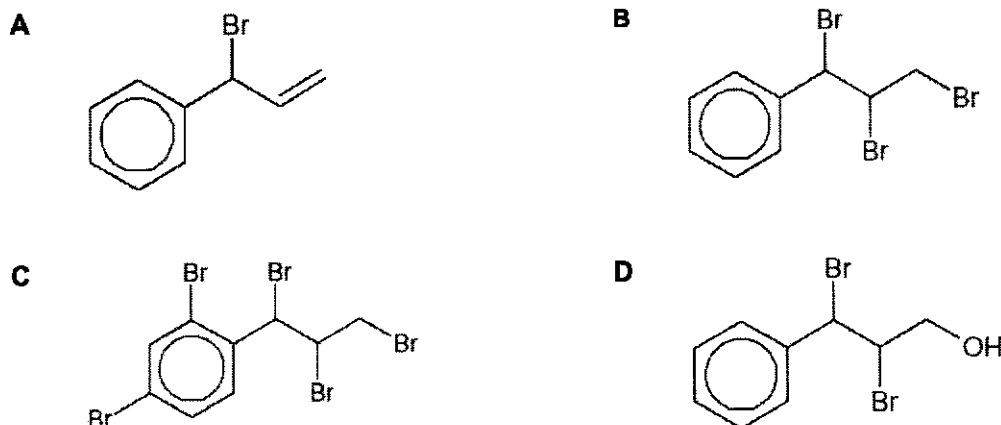
- A 1 only
- B 1 and 2 only
- C 2 and 3 only
- D 1, 2 and 3

[Turn over

- 15 Which of the following products will be formed when prop-2-enylbenzene is mixed with cold Br_2 in CCl_4 , in the presence of UV light?



prop-2-enylbenzene



- 16 Which of the following statements are true about benzene?

- 1 The C–C bond has a bond order of between 1 and 2.
- 2 It is able to conduct electricity due to delocalised electrons.
- 3 It is a planar molecule with all bond angles being 120° .
- 4 It undergoes addition reactions readily due to its C=C double bonds.

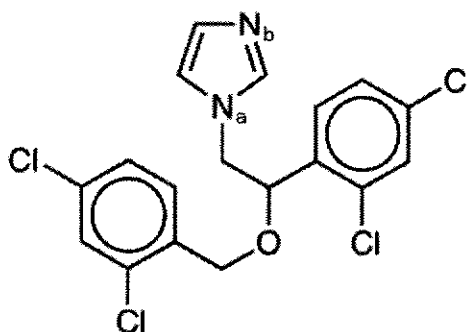
- A** 1 and 3 only **B** 2 and 4 only **C** 3 and 4 only **D** 1, 2 and 3 only

- 17 Chloroethane is heated with NaOH separately in aqueous and ethanolic medium, producing the major products **Q** and **T** respectively.

Which of the following statements is true about **Q** and **T**?

- A** The M_r of **Q** is heavier than the M_r of **T** by 18.0.
- B** Both **Q** and **T** are polar covalent compounds.
- C** **Q** has a non-superimposable mirror image.
- D** **T** has hydrogen bonding between its molecules.

- 18 Miconazole cream is used to treat fungal skin infections.



Which of the following statements are true about miconazole?

[The C–O–C group is considered inert.]

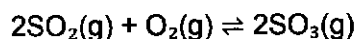
- A There is p-orbital overlap between the atom N_a and π electron cloud adjacent to it.
- B When boiled with $\text{NaOH}(\text{aq})$, cooled and neutralised with $\text{HNO}_3(\text{aq})$, it gives a white precipitate upon addition of $\text{AgNO}_3(\text{aq})$.
- C The N_a atom on miconazole acts as a stronger base than N_b .
- D The product of hydrolysis gives a dark colouration with neutral $\text{FeCl}_3(\text{aq})$.
- 19 The radioactive decay of ^{212}Pb into ^{212}Bi has a half-life of 10.6 hours.
- Given that radioactive decay observes first-order kinetics, how much time does it take for 85% of a ^{212}Pb sample to be converted to ^{212}Bi ?
- A 2.5 hours
- B 9.0 hours
- C 18.0 hours
- D 29.0 hours
- 20 Lactose is a sugar that is usually found in milk. In the human body, the enzyme, lactase, hydrolyses lactose, turning it into galactose and glucose. Lactose intolerance occurs when a person's digestive tract does not produce sufficient lactase to break down lactose.

Which of the following statements is **false** about the hydrolysis of lactose when a lactose-intolerant person drinks milk?

- A The substrate concentration far exceeds the enzyme concentration.
- B The order of reaction for the hydrolysis of lactose tends to 0.
- C The enzyme activity of lactase is specific to lactose only.
- D There is a lower average kinetic energy for the hydrolysis to occur.

[Turn over

- 21 The oxidation of sulfur dioxide in the Contact Process has the following equation.

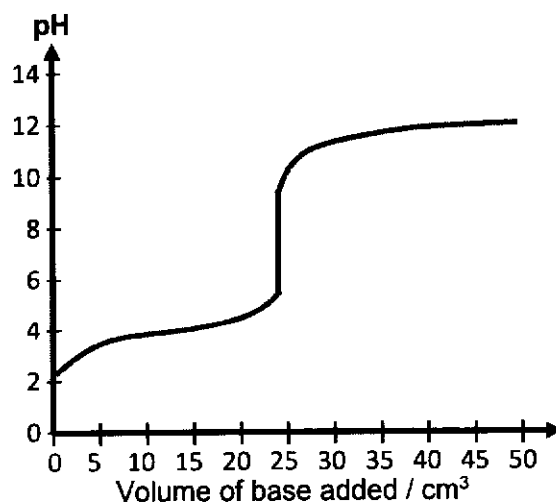


SO_2 and O_2 gas were added to an evacuated vessel in a 2:1 molar ratio and allowed to reach equilibrium.

Given that the equilibrium has a K_p value of 5 atm^{-1} and that the partial pressure of $\text{SO}_3(\text{g})$ at equilibrium was 25.6 atm, what is the partial pressure of $\text{SO}_2(\text{g})$ in the system at equilibrium?

- A 3.2 atm B 6.4 atm C 7.2 atm D 9.6 atm

- 22 Which of the following indicators is the most suitable for determining the end-point of the following titration?



	indicator	working pH range
A	cresol red	0.2 - 1.8
B	methyl yellow	2.9 - 4.0
C	phenol red	6.4 - 8.0
D	alizarin yellow R	10.0 - 12.0

- 23 30.0 cm³ of 0.100 mol dm⁻³ propylamine, CH₃CH₂CH₂NH₂, was titrated against 0.150 mol dm⁻³ HCl(aq) at constant temperature. When half the volume of HCl(aq) needed to reach equivalence point was added, the pH of the solution was 10.54.

Given that the pK_b of propylamine is 3.32 at the temperature in which the reaction was carried out, which of the following statements are correct?

- 1 The reaction was carried out at a temperature higher than 25 °C.
- 2 The volume of HCl(aq) needed to reach equivalence point is 20.0 cm³.
- 3 The initial pH of the propylamine solution was 11.84.

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

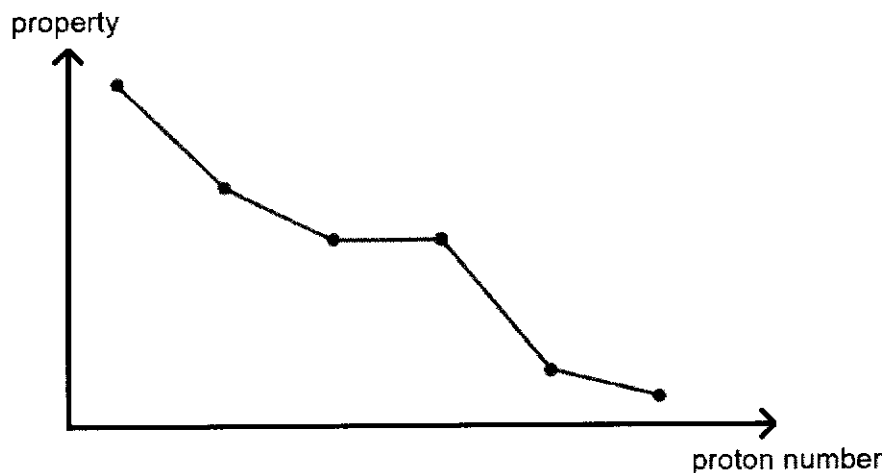
- 24 Solid sodium carbonate, Na₂CO₃, is added gradually added to a solution containing a mixture of Mg²⁺, Ca²⁺ and Ag⁺ ions, each at 0.002 mol dm⁻³.

compound	K_{sp}
MgCO ₃	3.6×10^{-8}
CaCO ₃	2.8×10^{-9}
Ag ₂ CO ₃	8.4×10^{-12}

What is the order of precipitation of the carbonates?

	first	last	
A	MgCO ₃	CaCO ₃	Ag ₂ CO ₃
B	MgCO ₃	Ag ₂ CO ₃	CaCO ₃
C	Ag ₂ CO ₃	CaCO ₃	MgCO ₃
D	CaCO ₃	Ag ₂ CO ₃	MgCO ₃

- 25 The following graph depicts a physical property belonging to either consecutive Period 3 elements, or the chlorides or oxides of consecutive Period 3 elements.



What is the physical property depicted?

- A** electrical conductivity
B electronegativity
C melting point
D pH in water
- 26 Compounds **X** and **Y** are either oxides or chlorides of Period 3 elements. Both **X** and **Y** exist as white solids at room temperature.

X is highly soluble in water, forming a solution which turns litmus red.

Y is slightly soluble in water, forming a solution which turns litmus blue.

What are the likely identities of compounds **X** and **Y**?

	X	Y
A	sodium chloride	phosphorus pentoxide
B	magnesium oxide	aluminium chloride
C	magnesium chloride	silicon dioxide
D	aluminium chloride	magnesium oxide

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

A metallic trophy was to be electroplated with a thin layer of gold with a thickness of 6×10^{-5} cm in an electrolyte consisting of Au^{3+} ions.

Given that the surface area of the trophy is 1381 cm^2 , and that the density of gold is 19.3 g cm^{-3} , how much time would it take to complete the electroplating using a current of 1 A?

- A 783 s
- B 2350 s
- C 27200 s
- D 81600 s

28 Which of the following statements are **not** true about the anodisation of aluminium?

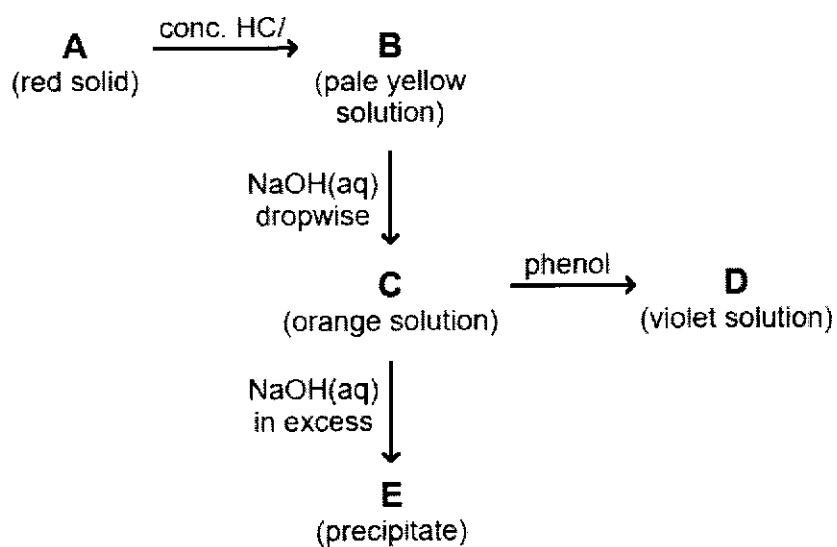
- 1 Aluminium is oxidised by oxygen.
- 2 Al atoms are oxidised to $\text{Al}^{3+}(\text{aq})$ ions.
- 3 The mass of the Al layer that was oxidised increases by 88.9%.

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

29 Which of the following statements about transition metals is **not** true?

- A Transition metals typically have lower melting and boiling points compared to s-block metals.
- B Transition metals and their compounds often act as catalysts due to their variable oxidation states.
- C Transition metals form coloured ions due to the presence of partially filled d-orbitals.
- D Transition metals are less reactive than Group 1 metals towards air and water.

30 Consider the following reactions.



What is the identity of **B**?

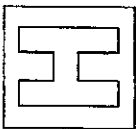
- A** CrO_4^{2-} **B** $[\text{CuCl}_4]^{2-}$ **C** $[\text{FeCl}_4]^-$ **D** $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$

END OF PAPER 1

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Candidate Name: _____



2024 Preliminary Examinations
Pre-University 3

H2 CHEMISTRY

Paper 1 Multiple Choice

9729/01
18th Sep 2024
1 hour

Additional materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, class and admission number in the spaces provided at the top of this page and on the Multiple Choice Answer Sheet provided.

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 Multiple Choice Answer Sheet provided.

Read the instructions on the Multiple Choice 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 question paper.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
TOTAL (30 marks)	

DA	1	2	3	4	5	6	7	8	9	10
A	4.7%	2.3%	4.7%	10.5%	2.3%	7.0%	24.4%	18.6%	10.5%	3.5%
B	4.7%	2.3%	7.0%	10.5%	20.9%		10.5%			
C	11.6%	2.3%	27.9%		10.5%	9.3%	11.6%			32.6%
D	3.5%	2.3%		4.7%	18.6%	8.1%				7.0%

DA	11	12	13	14	15	16	17	18	19	20
A			29.1%	30.2%					8.1%	7.0%
B		4.7%		11.6%	35.6%	18.6%	18.6%	12.8%	31.4%	
C	2.3%	9.3%	17.4%	3.5%	27.9%	3.5%	17.4%	32.6%	20.9%	9.3%
D	7.0%		4.7%	12.8%	2.3%	36.0%	19.8%	11.6%		

DA	21	22	23	24	25	26	27	28	29	30
A	23.3%	0.0%	10.5%		12.8%	16.3%	18.6%			9.3%
B		2.3%		3.5%	1.2%	18.6%		13.1%	4.7%	22.1%
C	23.3%		18.6%		22.1%	15.1%	24.4%		4.7%	
D	11.6%	9.3%	37.6%				2.3%		12.8%	15.1%

Answer Key:

1	2	3	4	5	6	7	8	9	10
A	A	D	C	C	B	D	D	B	B

11	12	13	14	15	16	17	18	19	20
B	A	A	B	B	A	A	A	D	D

21	22	23	24	25	26	27	28	29	30
B	C	B	D	D	D	B	A	A	C

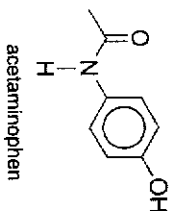
Section A

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

- 1 Which of the following statements are correct about 1 mole of C(s)?
- 1 It contains 6.02×10^{23} carbon atoms.
 - 2 It has a mass of 12.0 g.
 - 3 It contains 12 moles of electrons.
 - 4 It occupies a volume of 24.0 dm³ at room temperature and pressure.

- A 1 and 2 only B 3 and 4 only C 1, 2 and 3 only D 2, 3 and 4 only
- 1 – True. 1 mole of carbon contains $1 \times 6.02 \times 10^{23}$ atoms (Avogadro's number).
 - 2 – True. Mass of C = amount \times Ar = $1 \times 12.0 = 12.0$ g
 - 3 – Not true. 1 mole of C contains 6 mole of protons and 6 mole of electrons.
 - 4 – Not true. Carbon is a solid at room temperature and pressure and is not a gas (24.0 dm³ is the molar volume of gas), thus C will occupy a volume depending on the density of the allotrope.
- (Ans: A – 1 and 2 only)

- 2 A painkiller pill contains 500 mg of acetaminophen, C₉H₉NO₂.



What is the mass of nitrogen present in one pill?
[1 g = 1000 mg]

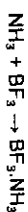
- A 0.046 g B 0.093 g C 0.151 g D 0.700 g

$$M_r \text{ of } C_9H_9NO_2 = 8(12.0) + 9(1.0) + 14.0 + 2(16.0) = 151.0$$

$$\text{Mass of nitrogen in one pill} = \frac{14.0}{151.0} \times 0.500 \text{ g} = 0.04636 \text{ g} = 0.046 \text{ g}$$

(Ans: A)

- 3 Ammonia reacts with boron trifluoride in the following equation.



What is the role of NH₃ in the reaction?

- A Brønsted-Lowry acid
B Brønsted-Lowry base
C Lewis acid
D Lewis base

Brønsted-Lowry acid is a H⁺ donor while Brønsted-Lowry base is a H⁺ acceptor.

N or NH₃ has a lone pair which can be donated (Lewis base) into the energetically accessible vacant 2p orbital of B in BF₃ (Lewis acid).

(Ans: D)

- 4 When excess potassium iodide, KI, is added to potassium iodate(V), iodine is produced.



Which of the following statements is **Incorrect** about the reaction?

- A Iodine in IO₃⁻ was reduced.
B Iodine in I⁻ was oxidised.
C The reaction is a disproportionation reaction.
D The oxidation number of iodine in I₂ is 0.

A – True. Oxidation number of I in IO₃⁻ is +5 and it decreases to 0 in I₂ (reduced).

B – True. Oxidation number of I in I⁻ is -1 and it increases to 0 in I₂ (oxidised).

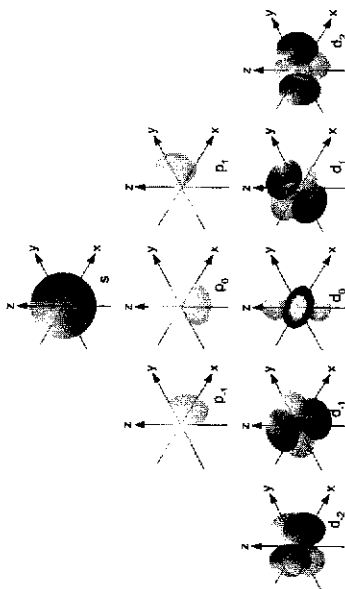
C – Not true. Disproportionation is when one species simultaneously undergoes reduction and oxidation. In this case, two different species are undergoing reduction and oxidation separately (to form the same product – the reverse of disproportionation – called comproportionation)

D – True. The oxidation numbers of both I atoms must be the same (no electronegativity difference between the two atoms) and must add up to 0 (no overall charge).

(Ans: C)

5 Which of the following statements is not true of an element in Period 3?

- A It has electrons in the spherically shaped orbitals.
- B It has three dumb-bell shaped orbitals in its outermost shell.
- C It has five orbitals with four lobes in each orbital.
- D It is able to accommodate more than 8 electrons in its outermost shell.



A – True. Spherically shaped orbitals refer to s orbitals, of which an element in Period 3 does have electrons in the 1s, 2s and 3s orbitals.

B – True. The outermost shell of Period 3 elements contain the 3s, 3p and 3d subshells, of which the dumb-bell shaped orbitals are the three 3p orbitals oriented perpendicularly (or orthogonally) to each other: 3p_x, 3p_y, 3p_z.

C – Not true. The orbitals with four lobes are the 3d orbitals (3d_{xy}, 3d_{xz}, 3d_{yz}, 3d_{x²-y²}) and there are only 4, not 5, of them. The 3d_{z²} orbital has two lobes and a ring.

D – True. The outermost shell can contain $2 + 6 + 10 = 18$ electrons (> 8).
(1 orbital $\times 2e^- = 2e^-$ in 3s, 3 orbitals $\times 2e^- = 6e^-$ in 3p, 5 orbitals $\times 2e^- = 10e^-$ in 3d)
(Ans: C)

6 A beam of $^{23}_{11}\text{Na}^+$ ions were passed through an electric field and it was found to deflect by an angle of $+8.5^\circ$.

What is the angle of deflection for a beam of $^{31}_{15}\text{P}^{3-}$ ions travelling at the same speed through the same electric field?

- A -34.4°
- B -18.9°
- C -18.7°
- D -3.8°

Angle of deflection $\propto \frac{\text{charge}}{\text{mass}}$

Angle of deflection = $k \left(\frac{\text{charge}}{\text{mass}} \right)$

$+8.5 = k \left(\frac{+1}{23} \right)$

$k = +195.5$

Angle of deflection = $k \left(\frac{\text{charge}}{\text{mass}} \right)$

$$= (+195.5) \left(\frac{-3}{31} \right)$$

$$= -18.9^\circ$$

(Ans: B)

7 Which of the following correctly describe the structure and bonding in carbon?

1 It contains strong C-C covalent bonds.

2 It can contain weak instantaneous dipole-induced dipole forces of attraction.

3 It can have a giant lattice structure.

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

1 – True as carbon forms giant covalent structures such as in graphite (each C covalently bonded to 3 other C atoms) or diamond (each C covalently bonded to 4 other C atoms).

2 – True as in graphite, each layer of C atoms (in a hexagonal repeating pattern) is not covalently bonded to the adjacent layers but only has weak instantaneous dipole-induced dipole forces of attraction.

3 – True as in diamond, the carbon atoms are arranged tetrahedrally in a giant repeating pattern (lattice).

(Ans: D – 1, 2 and 3)

- 8 An unknown element J exists as a liquid at 35 °C and is electrically conductive in both the solid and liquid states.

Another unknown element K exists as a gas at 35 °C and does not conduct electricity in both the solid and liquid states.

Which of the following statements are false about the compound formed between J and K?

- A It could conduct electricity in the molten state.
 B It could exist as non-polar molecules.
 C It could have the formula JK₂.
 D It could contain delocalised electrons.

For an element to be electrically conductive in both solid and liquid states, it has to be a metal with delocalised electrons. Two such metals that fit the bill of being liquid at 35 °C are mercury (which students should know) and gallium.

An element that is a gas and does not conduct electricity has to have either a simple molecular structure or giant covalent structure. Some examples are hydrogen, nitrogen, oxygen, fluorine, chlorine gas.

The compound is formed between the metal and non-metal, therefore

- A – True as the compound tends to be ionic, which can conduct electricity in the molten state due to the presence of mobile ions which act as mobile electrical charge carriers;
 B – True as students should recall that AlCl₃ is an example of a non-polar molecule formed between a metal and non-metal. In this case, by extending the properties of group 13 metals, GaCl₃ could / should similarly be a non-polar simple molecule.
 C – True as metals that form M²⁺ cations forms an ionic compound with the formula JK₂. In this case, mercury forms HgCl₂.
 D – False as both ionic compounds or simple covalent compounds do not contain delocalised electrons.
 (Ans: D)

- 9 Which of the following statements correctly describe ideal gas behaviour?

- A 1 mol of oxygen gas occupies 22.7 dm³ at room temperature and pressure.
 B 1.06 mol of carbon dioxide gas occupies 24.0 dm³ at standard temperature and pressure.
 C At low temperatures, nitrogen gas turns into a liquid.
 D At constant pressure, concentration of hydrogen gas increases when temperature increases.

Regardless of the identity of gas, as long as behaviour is ideal, it follows $pV = nRT$

- A – False. 1 mol of ideal gas occupies 24.0 dm³ at r.t.p., not 22.7 dm³.

$$pV = nRT$$

$$(101325)V = 1(8.31)(293)$$

$$V = 0.0240 \text{ m}^3 = 24.0 \text{ dm}^3$$

- B – True.

$$pV = nRT$$

$$(10^5)V = (1.06)(8.31)(273)$$

$$V = 0.024047 \text{ m}^3 = 24.047 \text{ dm}^3 = 24.0 \text{ dm}^3 \text{ (3 s.f.)}$$

- C – False. For a gas to turn into a liquid, the molecules come closer together and attract each other, forming significant intermolecular forces of attraction, releasing energy in the process. Ideal gases do not have intermolecular forces of attraction and theoretically remains as a gas even when approaching absolute zero (0 K).

- D – False. $p = cRT$, at constant P, c is inversely proportional to T hence concentration of gases should decrease when T increases.
 (Ans: B)

- 10 In an isolated system, a 2.5 dm³ vessel containing neon gas at -43 °C and 80 kPa was connected to a 5.5 dm³ vessel containing helium gas at -97 °C and 39 kPa. The valve was opened and the gases were allowed to mix.

The final pressure of the mixture was found to be 59 kPa.

Assuming ideal gas behaviour, what is the final temperature of the mixture?

- A -18 °C B ~~47 °C~~ C -70 °C D -116 °C

$$p_1V_1/T_1 + p_2V_2/T_2 = p_1V_1/T_1$$

$$(80)(2.5)/(273-43) + (39)(5.5)/(273-97) = (59)(2.5+5.5)/T_1$$

$$0.8696 + 1.219 = 472/T_1$$

$$T_1 = 226 \text{ K} = 226 - 273 = -47 \text{ °C}$$

- (Ans: B)

11 Which of the following equations represents the standard enthalpy change of atomisation of the species?

- A $\frac{1}{2}\text{Br}_2(\text{g}) \rightarrow \text{Br}(\text{g})$
 B $\text{Hg}(\text{l}) \rightarrow \text{Hg}(\text{g})$
 C $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
 D $\text{Na}(\text{s}) \rightarrow \text{Na}^+(\text{g})$

Definition of $\Delta H_{\text{atom}}^\ominus$ is the heat energy change when 1 mole of gaseous atoms is formed from its elements their standard states under standard conditions of 298 K and 1 bar.

- A – False. Br_2 is a liquid as an element; its standard state, not gas.
 B – True. Mercury exists as a liquid metal.
 C – False. Liquid water is not an element but a compound + it turned into gaseous molecules instead of atoms. This equation represents the enthalpy change of vapourisation instead.
 D – False. The product should be $\text{Na}(\text{g})$ atoms not $\text{Na}^+(\text{g})$ ions. This equation represents $\Delta H_{\text{atom}}^\ominus + 1^{\text{st}} \text{I.E.}$

(Ans: B)

12 Which of the following statements help to explain why the enthalpy change of solution of sodium chloride is endothermic?

- A The lattice energy is more exothermic than the sum of the hydration energies of the ions.
 B The lattice energy is less exothermic than the sum of the hydration energies of the ions.
 C The energy released from the formation of ion-dipole interactions is sufficient to overcome the ionic bonds.
 D The energy released from the formation of ion-dipole interactions is insufficient to overcome the ionic bonds.

A – True. $\text{L.E.} + \Delta H_{\text{soln}} = \Sigma \Delta H_{\text{hyd}}$, Rearranging, $\Delta H_{\text{soln}} = \Sigma \Delta H_{\text{hyd}} - \text{L.E.}$

Since both L.E. and ΔH_{hyd} are exothermic / negative in value, the term '-L.E.' will be positive. For the overall value to be positive, '-L.E.' must be larger in magnitude than $\Sigma \Delta H_{\text{hyd}}$.

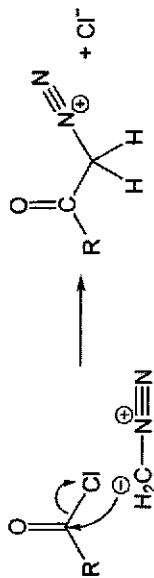
Hence L.E. must be more exothermic than $\Sigma \Delta H_{\text{hyd}}$.

B – False. (See explanation in A)

C & D – False because this explanation is for why an ionic compound is soluble/insoluble in water, but not about why it is endothermic. It includes heat transfer from the surrounding body of water into the dissolution process, thereby resulting in the temperature drop of water (endothermic process).

(Ans: A)

13 Consider the following reaction mechanism.



Which of the following statements about the reaction is incorrect?

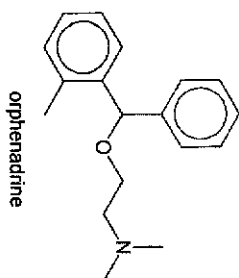
- A CH_2N_2 acts as an electrophile.
 B CH_2N_2 acts as a Lewis base.
 C CH_2N_2 acts as a nucleophile.
 D It is a substitution reaction.

Lone pair of electrons on C of CH_2N_2 is donated (nucleophile / Lewis base) into electrophilic carbon atom of R-CCl ; resulting in the heterolytic cleavage of C-Cl ; producing a leaving group Cl^- (substitution).

Hence, the overall is a nucleophilic substitution reaction.

(Ans: A)

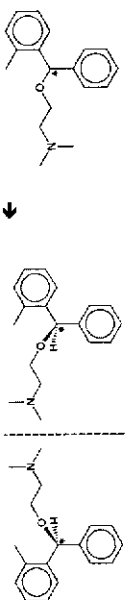
14 Which of the following statements are true about orphenadrine?



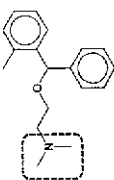
- 1 It can exhibit enantiomerism.
- 2 It has a pK_a that is greater than 7 at 25 °C.
- 3 It has the molecular formula $C_{16}H_{23}NO$.

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

1 – True as a chiral carbon exists (*), which means orphenadrine can exist as enantiomers (non-superimposable mirror images of each other)

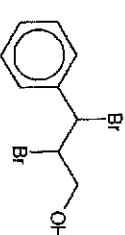
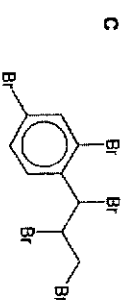
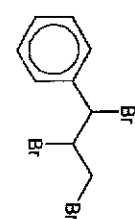
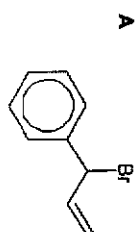


2 – True as the tertiary amine group is basic (therefore $pK_a > 7$, or $pK_b < 7$, at 25 °C) as it has a lone pair of electrons on N which can be donated to a H^+ .



3 – False. The molecular formula of orphenadrine is $C_{16}H_{23}NO$ (not 16 carbons).
(Ans: **B** – 1 and 2 only)

15 Which of the following products will be formed when prop-2-enylbenzene is mixed with cold Br_2 in CCl_4 , in the presence of UV light?



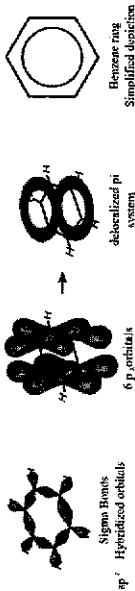
Recognise there are 3 types of reaction that can take place:

- Free radical substitution of H atom with Br on alkyl side chain
 - Possible as UV light present
 - Electrophilic addition of Br_2 across alkene (C=C)
 - Takes place the most readily without heat or UV, eliminate **A**.
 - Br_2 is in non-polar organic solvent CCl_4 , water (H_2O nucleophile) is absent to interfere in 2nd step of the electrophilic addition, eliminate **D**.
 - Electrophilic substitution of aryl group (benzene ring)
 - Absence of a halogen carrier / catalyst (like $AlCl_3$, $FeBr_3$), the Br_2 is not sufficiently electrophilic (induced δ^+ not electron deficient enough) for reaction with the aryl group. Electrophilic substitution will not take place under the given conditions, eliminate **C**.
- (Ans: **B**)

16 Which of the following statements are true about benzene?

- 1 The C-C bond has a bond order of between 1 and 2.
- 2 It is able to conduct electricity due to delocalised electrons.
- 3 It is a planar molecule with all bond angles being 120°.
- 4 It undergoes addition reactions readily due to its C=C double bonds.

- A 1 and 3 only B 2 and 4 only C 3 and 4 only D 1, 2 and 3 only



1 – True. The carbon-carbon bonds in benzene have identical lengths of 139 pm each. This is roughly in between those of a C=C double bond (134 pm) and a C-C single bond (154 pm), which implies that the C-C bond in benzene is stronger than a C-C single bond but weaker than a C=C double bond.

2 – False. Benzene has a simple molecular structure. Although benzene has delocalised electrons across its six C atoms in one molecule, the delocalised electrons are unable to transmit / move from one molecule of benzene to another. (The electrons are “stuck” or localised to the molecule). Therefore, benzene is unable to conduct electricity.

3 – True. All carbon atoms in benzene are sp^2 hybridised / 3 bond pairs and 0 lone pairs → trigonal planar in shape, and all the atoms form a planar molecule.

4 – False. Benzene does not contain C=C double bonds but a delocalised π electron cloud of 6 electrons in a ring, which results in aromatic stability. Undergoing electrophilic addition reactions will result in the disruption of the aromatic stability (which requires extremely harsh conditions to achieve). Therefore benzene does not undergo electrophilic addition, but undergoes electrophilic substitution instead to maintain the aromatic stability.

(Ans: A – 1 and 3 only)

17 Chloroethane is heated with NaOH separately in aqueous and ethanolic medium, producing the major products Q and T respectively.

Which of the following statements is true about Q and T?

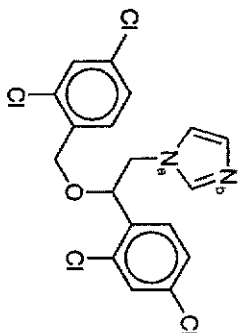
- A The M_r of Q is heavier than the M_r of T by 18.0.
- B Both Q and T are polar covalent compounds.
- C Q has a non-superimposable mirror image.
- D T has hydrogen bonding between its molecules.



A – True. CH_3CH_2OH (Q) has 2 H atoms and 1 O atom (additional 18.0) more than $CH_2=CH_2$ (T)
 B – False. While both are simple covalent, CH_3CH_2OH (Q) is polar but $CH_2=CH_2$ (T) is non-polar.
 C – False. CH_3CH_2OH (Q) does not contain chiral carbons / does not exist as enantiomers. Each carbon in Q are bonded to at least two identical groups (has at least two C-H).

D – False. $CH_2=CH_2$ (T) does not contain highly electronegative F, O, N atoms and hence it does not have hydrogen bonding between its molecules (only instantaneous dipole-induced dipole).
 (Ans: A)

18 Miconazole cream is used to treat fungal skin infections.



Which of the following statements are true about miconazole?
[The C–O–C group is considered inert.]

- A** There is p-orbital overlap between the atom N₆ and π electron cloud adjacent to it.
B When boiled with NaOH(aq), cooled and neutralised with HNO₃(aq), it gives a white precipitate upon addition of AgNO₃(aq).

C The N₆ atom on miconazole acts as a stronger base than N₈.

D The product of hydrolysis gives a dark colouration with neutral FeCl₃(aq).

Explanations for options **A** & **C**.

Both N₆ and N₈ have one lone pair (non-bonding).

For atom N₆, it is possible to think of the orbitals of N₆ as either sp³ hybridised (3 single bonds + 1 lone pair = 4 electron domains) OR as sp² hybridised with the lone pair in the p-orbital. In this case the sp² orbitals would lie on the plane with the p-orbital extending out perpendicular to the plane, which can overlap sideways with the existing π-electron clouds on both sides to form a continuous ring of delocalised π-electrons. Since the lone pair can delocalise, it would be less available for donation to H⁺, hence, weaker base.

For atom N₈, it is possible to think of the hybridisation as sp² (2 bonds + 1 lone pair = 3 electron domains) + one unhybridised p-orbital involved in the π bond. Therefore the lone pair exists in one of the three sp² orbitals that is on the plane, pointed outwards from the ring. Since this sp² orbital with the lone pair is not perpendicular to the plane, the lone pair is not delocalised and is more available for donation to H⁺, hence, stronger base than N₆.

(For A-level syllabus, hybridisation is only applied to carbon in organic chem and usually not extended to atoms with lone pairs.)

B – nucleophilic substitution of Cl with OH⁻ does not take place due to (a) 3p orbital of Cl overlapping with π electron cloud of benzene, C–Cl is strengthened, insufficient energy to break, and (b) approach of OH⁻ nucleophile is hindered by repulsion from the high electron density of the benzene ring.

D – recognise that the C–O–C ether functional group is not taught, not the same as ester. No product of hydrolysis / no phenol formed. No reaction with neutral FeCl₃.
(Ans: **A**)

[Turn over

19 The radioactive decay of ²¹³Pb into ²¹³Bi has a half-life of 10.6 hours.

Given that radioactive decay observes first-order kinetics, how much time does it take for 85% of a ²¹³Pb sample to be converted to ²¹³Bi?

- A** 2.5 hours
B 9.0 hours
C 18.0 hours
D 29.0 hours

For 85% of the reaction to have proceeded, it would have passed 50% (one half-life), and passed 75% (two half-lives) but not yet reached 87.5% (three half-lives). Students are just required to know that the time taken is more than 2 half-lives to be able to work out **D** as the answer, i.e. more than 21.2 hours (2 × 10.6).

The calculation is as follows:

$$[\text{reactant}]_{\text{remaining}} = [\text{reactant}]_{\text{initial}} \times \left(\frac{1}{2}\right)^n, \quad \text{where } n = \text{no. of half-lives.}$$

$$15 = 100 \times \left(\frac{1}{2}\right)^n$$

$$\lg(15 / 100) = n \lg\left(\frac{1}{2}\right)$$

$$n = \lg(0.15) / \lg(0.5)$$

$$= 2.737$$

$$\text{Time elapsed} = 2.737 \times 10.6 = 29.0 \text{ hours}$$

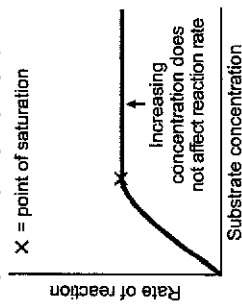
(Ans: **D**)

20 Lactose is a sugar that is usually found in milk. In the human body, the enzyme, lactase, hydrolyses lactose, turning it into galactose and glucose. Lactose intolerance occurs when a person's digestive tract does not produce sufficient lactase to break down lactose.

Which of the following statements is **false** about the hydrolysis of lactose when a lactose-intolerant person drinks milk?

- A The substrate concentration far exceeds the enzyme concentration.
- B The order of reaction for the hydrolysis of lactose tends to 0.
- C The enzyme activity of lactase is specific to lactose only.
- D There is a lower average kinetic energy for the hydrolysis to occur.

For a lactose intolerant person (very low [lactase]) who drank milk, the
 $[\text{lactose}] \gg [\text{lactase}]$ or $[\text{substrate}] \gg [\text{enzyme}]$ (A is True)



At high [substrate / lactose], the graph is a horizontal straight line. This is because all the active sites of the enzyme are used up, increasing [substrate / lactose] does not increase rate of reaction, therefore order of reaction w.r.t. [lactose] is 0 (i.e. rate is independent of [lactose] in this region). (B is True)

C – True. The activity of enzymes are usually specific, i.e. lactase only catalyses hydrolysis of lactose and not other substrates / molecules.

D – False. The average kinetic energy is only dependent on temperature and not due to the lower [enzyme / lactase]. (Ans: D)

21 The oxidation of sulfur dioxide in the Contact Process has the following equation.



SO_2 and O_2 gas were added to an evacuated vessel in a 2:1 molar ratio and allowed to reach equilibrium.

Given that the equilibrium has a K_p value of 5 atm^{-1} and that the partial pressure of $\text{SO}_3(\text{g})$ at equilibrium was 25.6 atm, what is the partial pressure of $\text{SO}_2(\text{g})$ in the system at equilibrium?

- A 3.2 atm
- B 6.4 atm
- C 7.2 atm
- D 9.6 atm

$$K_p = \frac{(P_{\text{SO}_3})^2}{[(P_{\text{SO}_2}]^2(P_{\text{O}_2})]}$$

Let $P_{\text{O}_2} = x$, therefore $P_{\text{SO}_2} = 2x$

$$5 = \frac{(25.6)^2}{[(2x)^2(x)]}$$

$$4x^3 = 131.072$$

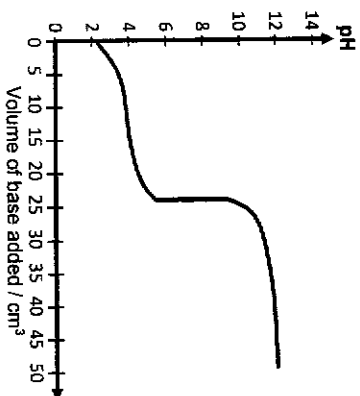
$$x^3 = 32.768$$

$$x = P_{\text{O}_2} = 3.2 \text{ atm}$$

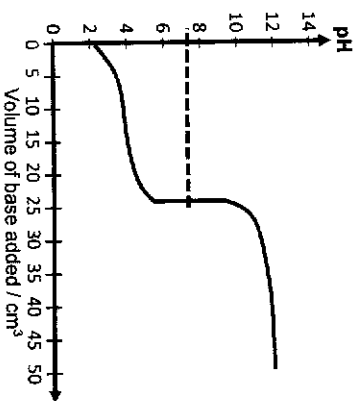
$$P_{\text{SO}_2} = 2x = 2(3.2) = 6.4 \text{ atm}$$

(Ans: B)

- 22 Which of the following indicators is the most suitable for determining the end-point of the following titration?



	indicator	working pH range
A	cresol red	0.2 - 1.8
B	methyl yellow	2.9 - 4.0
C	phenol red	6.4 - 8.0
D	alizarin yellow R	10.0 - 12.0



The mid-point of the equivalence line on the titration curve is somewhere between pH 7-8, which falls within the working pH range of phenol red (6.4-8.0), which is where the colour change will be the most obvious.
(Ans: C)

Turn over

- 23 30.0 cm³ of 0.100 mol dm⁻³ propylamine, CH₃CH₂CH₂NH₂, was titrated against 0.150 mol dm⁻³ HCl(aq) at constant temperature. When half the volume of HCl(aq) needed to reach equivalence point was added, the pH of the solution was 10.54.

Given that the pK_a of propylamine is 3.32 at the temperature in which the reaction was carried out, which of the following statements are correct?

- 1 The reaction was carried out at a temperature higher than 25 °C.
- 2 The volume of HCl(aq) needed to reach equivalence point is 20.0 cm³.
- 3 The initial pH of the propylamine solution was 11.84.

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

At ½ V_{eq}, half of the weak base has been neutralised to form the conjugate acid. At this point, it is a buffer solution at maximum buffer capacity. pOH = pK_a = 3.32.

As the experiment did not mention that the temperature was 25 °C, one should do a check for pK_w to ascertain if it is 14 (T = 25 °C) or not.

$$\begin{aligned} \text{p}K_w &= \text{pH} + \text{pOH} \\ &= 10.54 + 3.32 \\ &= 13.84 \end{aligned}$$

Since pK_w is lower than 14, it means that water has self-ionised more at this temperature and that the temperature is higher than 25 °C (more energy available for water to dissociate).
(Option 1 is true)

Amount of propylamine = 0.0300 × 0.100 = 0.00300 mol = amount of HCl required
Volume of HCl required = 0.00300 ÷ 0.150 = 0.0200 dm³ = 20.0 cm³ (Option 2 is true)

As propylamine is a weak base,

$$\begin{aligned} [\text{OH}^-] &\approx \sqrt{([\text{propylamine}]_{\text{initial}} \times K_b)} \\ &= \sqrt{(0.100 \times 10^{-3.32})} \\ &\approx \sqrt{(10^{-1} \times 10^{-3.32})} \\ &\approx \sqrt{(10^{-4.32})} \\ &\approx 10^{-2.16} \end{aligned}$$

$$\begin{aligned} \text{Initial pH of propylamine} &= 13.84 - \text{pOH} \\ &= 13.84 - (-\lg 10^{-2.16}) \\ &= 13.84 - 2.16 \\ &= 11.68 \text{ (Option 3 is false as p}K_w \text{ is not} = 14) \end{aligned}$$

(Ans: B - 1 and 2 only)

24 Solid sodium carbonate, Na_2CO_3 , is added gradually to a solution containing a mixture of Mg^{2+} , Ca^{2+} and Ag^+ ions, each at $0.002 \text{ mol dm}^{-3}$.

compound	K_{sp}
MgCO_3	3.6×10^{-8}
CaCO_3	2.8×10^{-9}
Ag_2CO_3	8.4×10^{-12}

What is the order of precipitation of the carbonates?

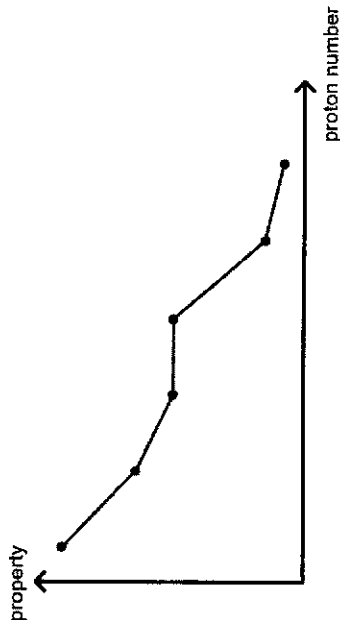
	first		last
A	MgCO_3	CaCO_3	Ag_2CO_3
B	MgCO_3	Ag_2CO_3	CaCO_3
C	Ag_2CO_3	CaCO_3	MgCO_3
D	CaCO_3	Ag_2CO_3	MgCO_3

For precipitation to occur, ionic $\text{Pdt} \geq K_{sp}$

MgCO_3	CaCO_3	Ag_2CO_3
$\text{Ionic Pdt} = K_{sp} = [\text{Mg}^{2+}][\text{CO}_3^{2-}]$ $3.6 \times 10^{-8} = (0.002)[\text{CO}_3^{2-}]$ $[\text{CO}_3^{2-}]$ for ppt $= 3.6 \times 10^{-6} / 0.002$ $= 1.8 \times 10^{-6} \text{ mol dm}^{-3}$	$\text{Ionic Pdt} = K_{sp} = [\text{Ca}^{2+}][\text{CO}_3^{2-}]$ $2.8 \times 10^{-9} = (0.002)[\text{CO}_3^{2-}]$ $[\text{CO}_3^{2-}]$ for ppt $= 2.8 \times 10^{-6} / 0.002$ $= 1.4 \times 10^{-6} \text{ mol dm}^{-3}$	$\text{Ionic Pdt} = K_{sp} = [\text{Ag}^+]^2[\text{CO}_3^{2-}]$ $8.4 \times 10^{-12} = (0.002)^2 [\text{CO}_3^{2-}]$ $[\text{CO}_3^{2-}]$ for ppt $= 8.4 \times 10^{-12} / (0.002)^2$ $= 2.1 \times 10^{-6} \text{ mol dm}^{-3}$
Highest $[\text{CO}_3^{2-}]$ for ppt \Rightarrow Last	Lowest $[\text{CO}_3^{2-}]$ for ppt \Rightarrow First	2nd

(Ans: D)

25 The following graph depicts a physical property belonging to either consecutive Period 3 elements, or the chlorides or oxides of consecutive Period 3 elements.



What is the physical property depicted?

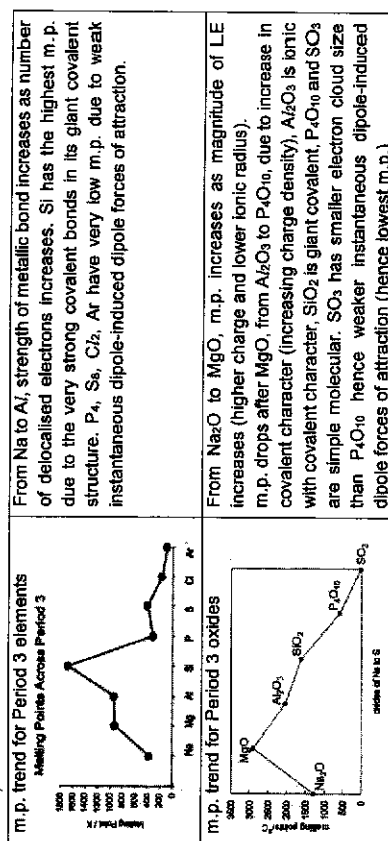
- A electrical conductivity
- B electronegativity
- C melting point
- D pH in water

For A, electrical conductivity increases from Na – Al, then drops to semiconductor Si, and to 0 from phosphorus to chlorine. (Graph goes up then down and flatlines)

(The chlorides or oxides of Period 3 elements do not conduct electricity in their standard states)

For B, electronegativity increases across the period due to increasing nuclear charge and negligible change in shielding effect, thus effective nuclear charge increases and attraction for the outermost electron increases. (Graph is an increasing line)

For C,



From Na to Al, strength of metallic bond increases as number of delocalised electrons increases. Si has the highest m.p. due to the very strong covalent bonds in its giant covalent structure. P, S, Cl, Ar have very low m.p. due to weak instantaneous dipole-induced dipole forces of attraction.

From Na_2O to MgO , m.p. increases as magnitude of LE increases (higher charge and lower ionic radius). m.p. drops after MgO , from Al_2O_3 to P_2O_5 , due to increase in covalent character (increasing charge density). Al_2O_3 is ionic with covalent character, SiO_2 is giant covalent, P_2O_5 and SO_2 are simple molecular. SO_2 has smaller electron cloud size than P_2O_5 hence weaker instantaneous dipole-induced dipole forces of attraction (hence lowest m.p.)

m.p. trend of Period 3 chlorides	NaCl and MgCl ₂ are giant ionic → high m.p. (drops slightly due to increase in covalent character from increase in charge density of cation)
	AlCl ₃ , SiCl ₄ , PCl ₅ are simple molecular → low m.p. Variations in m.p. among these 3 are due to strength of instantaneous dipole-induced dipole forces (electron cloud size)

For pH of Period 3 oxides in water,
 Na₂O dissolves in water to form pH ≈ 13-14
 MgO dissolves in water to form pH ≈ 8-9 (slightly soluble)
 Al₂O₃ and SiO₂ is insoluble in water hence pH = 7 (neutral)
 P₂O₅ / P₄O₁₀ dissolves readily in water to form H₃PO₃ / H₃PO₄ respectively pH = 3
 SO₂ / SO₃ dissolves readily in water to form H₂SO₃ / H₂SO₄ respectively pH ≈ 2
 (Ans: D)

26 Compounds X and Y are either oxides or chlorides of Period 3 elements. Both X and Y exist as white solids at room temperature.

X is highly soluble in water, forming a solution which turns litmus red.
 Y is slightly soluble in water, forming a solution which turns litmus blue.

What are the likely identities of compounds X and Y?

X	Y
A sodium chloride	phosphorus pentoxide
B magnesium oxide	aluminium chloride
C magnesium chloride	silicon dioxide
D aluminium chloride	magnesium oxide

X turns litmus red → X is acidic (Option A is eliminated as NaCl forms neutral solution in water)
 X is highly soluble in water (Option B is eliminated as MgO has low solubility in water)
 Y is slightly soluble → (Option C is eliminated as SiO₂ is insoluble in water)
 Y and turns litmus blue → Y is basic (MgO fits the bill + AlCl₃ is acidic and fits the description for X)
 (Ans: D)

[Turn over

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

A metallic trophy was to be electroplated with a thin layer of gold with a thickness of 6×10^{-3} cm in an electrolyte consisting of Au³⁺ ions.

Given that the surface area of the trophy is 1381 cm², and that the density of gold is 19.3 g cm⁻³, how much time would it take to complete the electroplating using a current of 1 A?

- A 783 s
 B 2350 s
 C 27200 s
 D 81600 s

Volume of gold = $1381 \times 6 \times 10^{-3} = 0.08286 \text{ cm}^3$
 Mass of gold = $19.3 \times 0.08286 = 1.5992 \text{ g}$
 Amt of gold = $1.5992 / 197 = 0.008118 \text{ mol}$
 Amt of electrons = $0.008118 \times 3 = 0.024353 \text{ mol}$
 $Q = nF = 0.024353 \times 96500 = 2350 \text{ J}$
 $t = Q / I = 2350 / 1 = 2350 \text{ s}$
 (Ans: B)

28 Which of the following statements are not true about the anodisation of aluminium?

- Aluminium is oxidised by oxygen.
- Al atoms are oxidised to Al³⁺(aq) ions.
- The mass of the Al layer that was oxidised increases by 88.9%.

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

For anodisation of aluminium, the reactions are:

Reaction at the Al anode: $2 \text{H}_2\text{O}(\text{l}) \rightarrow 4\text{H}^+(\text{aq}) + \text{O}_2(\text{g}) + 4\text{e}^-$

$4\text{Al}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Al}_2\text{O}_3(\text{s})$ (Option 1 is True, and 2 is False)

Reaction at the Pt cathode: $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$

Overall reaction: $2\text{Al}(\text{s}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow \text{Al}_2\text{O}_3(\text{s}) + 3\text{H}_2(\text{g})$

2 moles of Al(s) forms 1 mole of Al₂O₃(s)

Increase in mass is from 2(27.0) = 54.0 to 2(27.0)+3(16.0) = 102.0

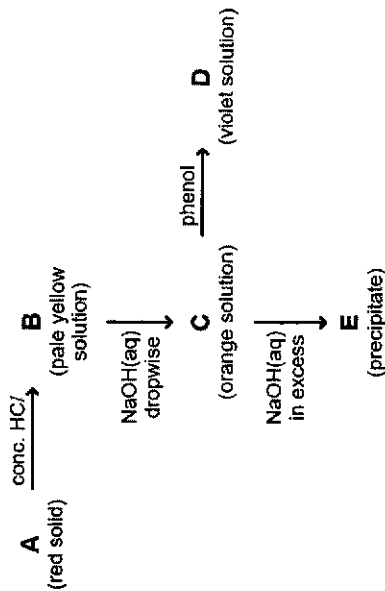
Therefore the percentage increase is = $\left(\frac{102.0-54.0}{54.0}\right) \times 100\% = 88.9\%$ (Option 3 is True).

(Ans: A – 2 only is incorrect)

29 Which of the following statements about transition metals is **not** true?

- A** Transition metals typically have lower melting and boiling points compared to s-block metals.
- B** Transition metals and their compounds often act as catalysts due to their variable oxidation states.
- C** Transition metals form coloured ions due to the presence of partially filled d-orbitals.
- D** Transition metals are less reactive than Group 1 metals towards air and water.
- A** is False - Transition metals generally have high melting and boiling points due to strong metallic bonding between cations with delocalised d electrons.
- B** is True - Variable oxidation states allow transition metals and their compounds to facilitate electron transfer in catalytic reactions.
- C** is True - Partially filled d orbitals in transition metal ions lead to d-d electron transitions which absorb visible light, resulting in colored compounds.
- D** is True - Transition metals are less reactive than Group 1 metals towards air water due to their higher ionisation energies.
- (Ans: A)

30 Consider the following reactions.



What is the identity of B?

- A** CrO_4^{2-} **B** $[\text{CuCl}_4]^{2-}$ **C** $[\text{FeCl}_4]^-$ **D** $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$

From **C** \rightarrow **D** it can be deduced that the orange solution **C** should be neutral FeCl_3 solution as it gives a positive test with phenol, and the reaction involves the Fe cation (Options **A** and **B** can be eliminated)

Solid **A** should be a form of Fe as a red solid (likely Fe_2O_3)

Given that from **A** \rightarrow **B**, concentrated HCl is used, it means that the oxide is neutralised and the Fe^{3+} ion forms a complex in a solution containing a very high concentration of Cl^- ions. Therefore the complex should be $[\text{FeCl}_4]^-$ instead of $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$.

B \rightarrow **C**, it is a slow neutralisation of the highly acidic environment, until neutral, and ligand exchange takes place (also in part due to dilution).

C \rightarrow **E** results in formation of $\text{Fe}(\text{OH})_3$ ppt.
(Ans: C)

