1 n(Be) present = $\frac{0.09}{9}$ = 0.01 mol **B**

no. of neutrons present per ${}^{9}_{4}Be$ atom = 5

∴ no. of neutrons present in 0.09 g of ${}^{9}Be$ = 5(0.01)L

= **0.05*L***

2 $ClO_2 + e^- \longrightarrow ClO_2^-$ [R] **C**

Since no. of electrons transferred must be equal

⇒ 1 mol of ClO_2 gained 1 mol of e

⇒ another 1 mol of ClO_2 lost 1 mol of e to form Q

⇒ O.N. of chlorine in Q changes from +4 (original) to **+5** (final)

FYI

$ClO_2 + 2OH^- \longrightarrow ClO_3^- + H_2O + e^-$ [O]

balanced equation: $2ClO_2 + 2OH^- \longrightarrow ClO_3^- + ClO_2^- + H_2O$

3 molecular formula of G = $C_7H_{12}O_3$ **A**

$C_7H_{12}O_3 + \frac{17}{2} O_2 \longrightarrow 7CO_2 + 6H_2O$

4 Presence of H covalently bonded to O and available lone pairs of electrons on O in both water and methanol, hence hydrogen bonds will be the strongest IMF. **A**
Methoxymethane does not have H covalently bonded to O, hence only permanent dipoles.

5 **A**

	no. of bp	no. of lp	shape should be
A,B	2	2	bent (non–linear)
C,D	3	1	trigonal pyramidal

6 The behaviour of real gas deviates from ideality because volume of gas particles is not insignificant compared to the overall volume occupied by the gas (option **D**). There are also significant intermolecular forces of attraction between the gas particles (option **C**), resulting in inelastic collisions (option **A**). **B**

7 Lattice energy is proportional to $\frac{q_+q_-}{(r_+ + r_-)}$. Thus the bigger the charge, and the smaller the inter–ionic distance, the more exothermic the lattice energy is. **A**

Size of cation: $Cs^+ > Na^+$; size of anion: $Cl^- > F^-$

Since Cs^+ and Cl^- are the larger cation and anion respectively, $CsCl$ will have the least exothermic lattice energy (–661 kJ mol^{-1}).

8 $\Delta H_r = \Sigma\Delta H_f$ (products) – $\Sigma\Delta H_f$ (reactants) **C**

= [–1273 + 6(0)] – [6(–394) + 6(–286)]

= +2807 kJ mol^{-1} **> 0**

As the forward reaction results in a formation of solid (with no change in no. of gaseous molecules), there will be less ways of arranging the particles and **Δ*S* is < 0**.

9 $Cl_2 + 2e \rightleftharpoons 2Cl^-$ +1.36 V **C**

$Br_2 + 2e \rightleftharpoons 2Br^-$ +1.07 V

$I_2 + 2e \rightleftharpoons 2I^-$ +0.54 V

$(SCN)_2 + 2e \rightleftharpoons 2SCN^-$ x V

Since both aq. Cl_2 and aq. Br_2 are able to oxidise SCN^- ion to $(SCN)_2$ while aq. I_2 is not able to, the $E^\ominus(SCN)_2/SCN^-$ must be less positive than +1.07 but more positive than +0.54.

10 rate = k [P] $[Q]^2$ **B**

If [P] is doubled while [Q] is halved, rate is halved. Hence only half of the volume collected in first experiment will be produced in the first minute of the 2nd experiment.

11 To determine the order of reaction wrt H^+ ions, we have to monitor how the rate of reaction changes as the concentration of H^+ ions is changed, while keeping all other factors constant. **C**

12 $[H^+] = [HNO_3]$ after dilution $= \frac{10 \times 0.01}{(90+10)}$ **C**

$= 0.001 \text{ mol dm}^{-3}$

pH = **3**

13 **B**

	$2H_2(g)$	$+ CO(g)$	$\rightleftharpoons$	$CH_3OH(g)$
initial amount	2.0	1.0		0
change in amount	$-x$	$-\frac{1}{2}x$		$+\frac{1}{2}x$
amount at eqm	$\mathbf{2.0 - x}$	$\mathbf{1.0 - \frac{1}{2}x}$		$\mathbf{\frac{1}{2}x}$
concentration at eqm	$\frac{(2.0 - x)}{0.5}$	$\frac{(1.0 - \frac{1}{2}x)}{0.5}$		$\frac{(\frac{1}{2}x)}{0.5}$

14 **B**

A bluish green – copper

B green – barium

C lilac – potassium

D orange/red/brick red - calcium

Group II metal	**colour of flame in oxygen**
Mg	intense / brilliant white
Ca	intense / brilliant white with tinge of red (brick–red)
Sr	almost white with tinge of red
Ba	white with pale green tinges

15 **B**

	deduction	**likely identity of Z**
A	Z is a metal.	could be sodium, magnesium or aluminium
B	Z is probably in Group V.	is phosphorus
C	Z is a covalent chloride.	could be aluminium or phosphorus based on the formula (ZCl_3)
D	Z forms an amphoteric hydroxide with NaOH.	is aluminium

Alternatively

Option **A** and **B** are mutually exclusive, while the conclusion for **C** is correct for both **A** and **B**. Hence **D** is the key to answering this question. Using your knowledge of $AlCl_3$ and PCl_3 with water, you can then conclude that Z is aluminium.

16 Dissolving $CuCl_2$ in water will give the **blue** $\mathbf{[Cu(H_2O)_6]^{2+}(aq)}$ and $Cl^-(aq)$. **D**

When concentrated HC*l* is added to an aqueous solution of Cu^{2+}, ligand exchange occurs where Cl^- displaces the H_2O ligands, forming the **yellow $[CuCl_4]^{2-}$**.

$$[Cu(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-} + 6H_2O$$

17 **Cold** condition **C**

$$Cl_2(g) + 2OH^-(aq) \longrightarrow Cl^-(aq) + ClO^-(aq) + H_2O(l)$$

Hot condition

The above reaction will take place 1st before the ClO^- formed undergoes further disproportionation

$$3ClO^-(aq) \longrightarrow 2Cl^-(aq) + ClO_3^-(aq)$$

Combining the 2 equations,

$$\mathbf{3Cl_2(g) + 6OH^-(aq) \longrightarrow 5Cl^-(aq) + ClO_3^-(aq) + 3H_2O(l)}$$

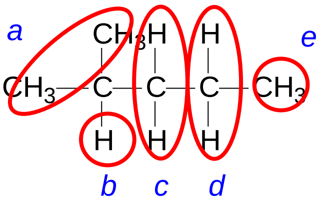
18 **A**

- **A** Down the group, the charge density of M^{2+} decreases since ionic radius increases.
- **B** Reactivity of Group II metals increases down the group.
- **C** $\Delta H_{solution}$ becomes more negative down the group and solubility increases.
- **D** From option **A** and since polarising power α charge density, extent of weakening of covalent bond in nitrate ion decreases and thermal stability increases.

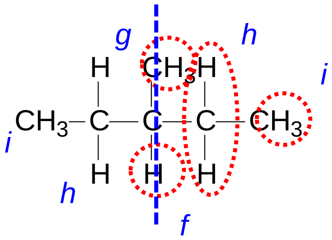
19 Given that the unknown is dibasic [2 x $-CO_2H$], you can deduce the molecular mass of the alkyl chain = 146 – 2(45) = 56. **C**

Hence, the no. of C atoms = **4** [56 ÷ 14 (each $>CH_2$)] **+ 2** (from $-CO_2H$) **= 6**.

20 **B**



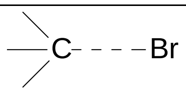
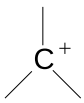
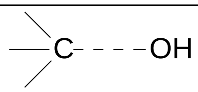
P



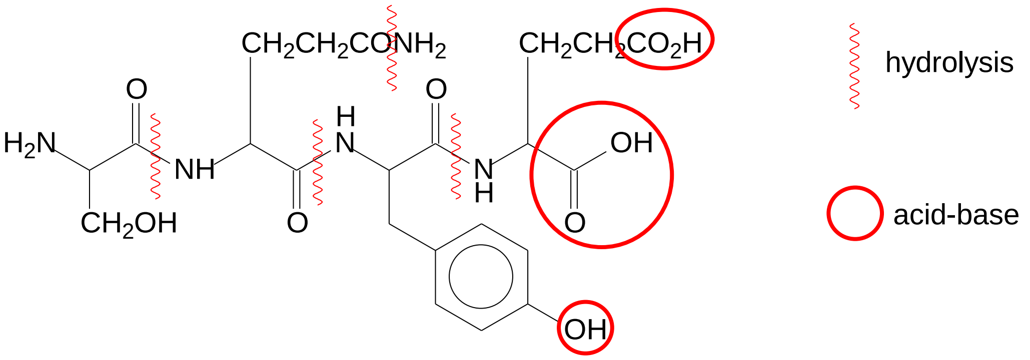
Q

Note: There is a plane of symmetry within a molecule of Q.

21 The reaction pathway involving bromoalkane shows a 2–step mechanism. Hence, you can conclude that it occurs via unimolecular nucleophilic substitution (S_N1). **A**

point	X	Y	Z
species present	 lengthening and subsequent breaking of C–Br bond	 trigonal planar carbocation intermediate formed	 attack on C^+ by OH^- nucleophile and subsequent forming of C–OH bond

22 **D**

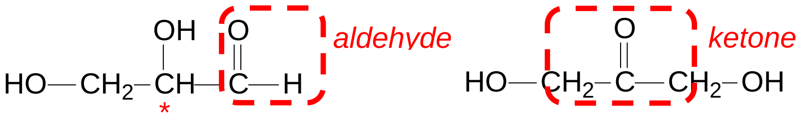


$RCO_2H + NaOH \longrightarrow RCO_2Na + H_2O$
$C_6H_5OH + NaOH \longrightarrow C_6H_5ONa + H_2O$
$RCONHR' + + NaOH \longrightarrow RCO_2Na + R'NH_2$

Since both hydrolysis and acid–base involves a 1:1 reacting mole ratio with NaOH, **0.7 mol** of NaOH (0.4 mol for hydrolysis and 0.3 mol for acid–base) will react with 0.1 mol of T.

Note: NaOH has no reaction with the alcohol present (RCH_2OH).

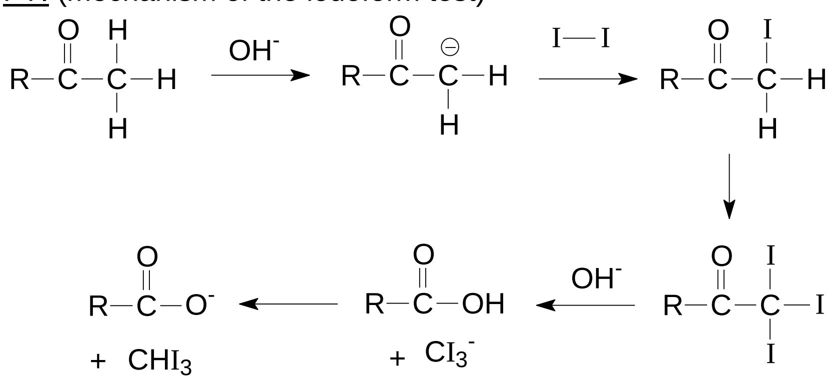
23 **D**



2,3-dihydropropanal 1,3-dihydropropanone

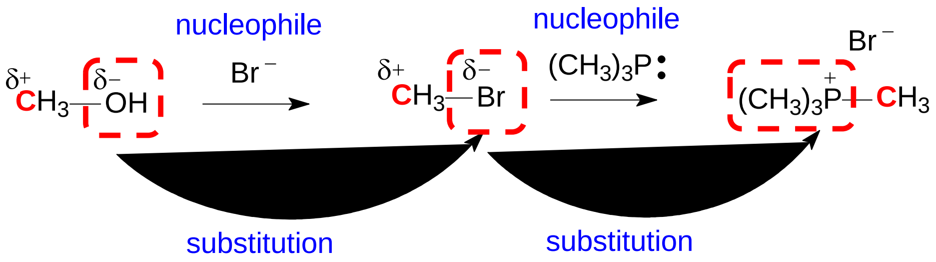
A only 2,3–dihydropropanal contains a chiral carbon.
B only 2,3–dihydropropanal gives silver precipitate.
C absence of $CH_3CH(OH)R$ and $CH_3COR \Rightarrow$ both do not give yellow precipitate.
D they have the same molecular ($C_3H_6O_3$) and empirical (CH_2O) formulae.

<u>FYI</u> (mechanism of the iodoform test)



Step 1: acid–base reaction
Step 4: nucleophilic (acyl) substitution
Step 4 and 5 can be combined and is known as base–catalysed hydrolysis

Hence it is not possible for both to give yellow precipitate with I_2/OH^-. However, $RCOCH_2I$ ($RCOCHI_2$, $RCOCI_3$) gives yellow precipitate with I_2/OH^-.

24 

D

25
A nucleophilic (acyl) substitution occurs readily and an immediate white precipitate would be observed. **D**
B nucleophilic substitution does not occur due to the <u>delocalisation of the lone pair of electrons</u> on the C*l* atom into the benzene ring, creating a <u>partial double bond character</u> in the C–C*l* bond.
C same as A
D nucleophilic substitution <u>occurs upon boiling with NaOH(aq)</u> and the resulting mixture contains Cl^- ions. upon cooling, acidification and addition of $AgNO_3$(aq), white precipitate would be observed.

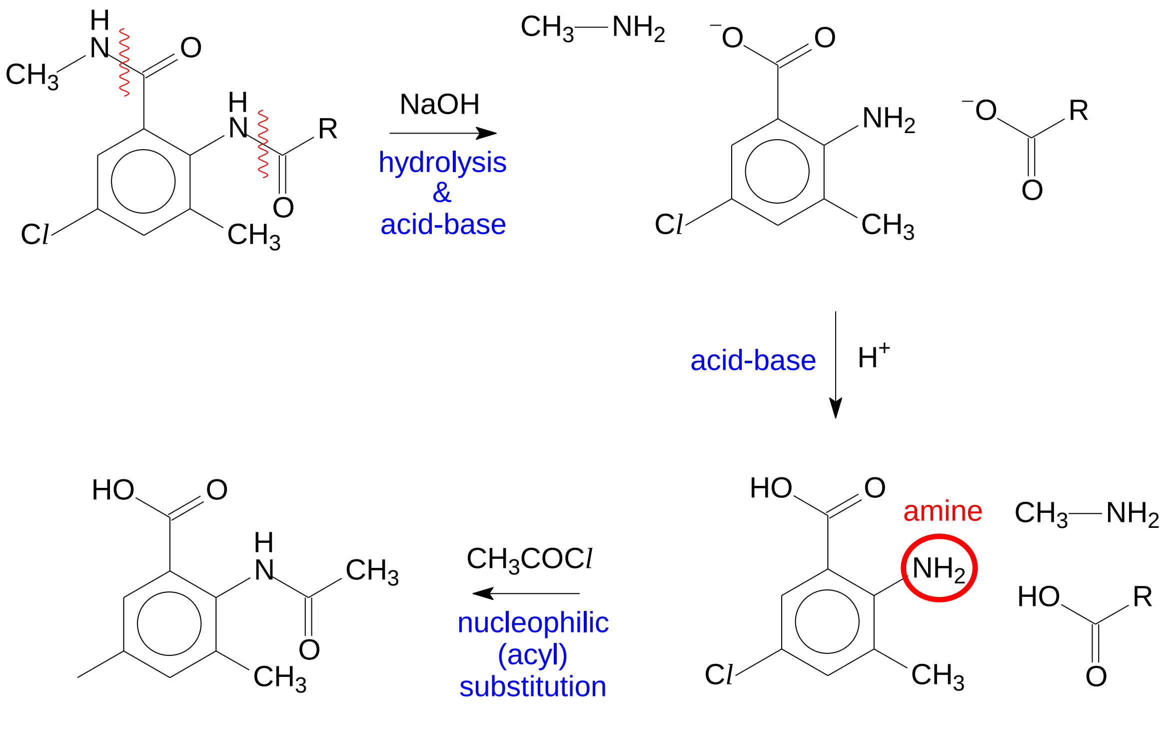
26 **C**

ala–gly
lys–ser
ser–gly–ala
met–ala
gly–lys

met–ala–gly–lys–ser–gly–ala

Peptide P contains 7 amino acid residues.

<u>Alternatively</u>
A not possible to get gly-lys and ser-gly-ala fragments
B not possible to get gly-lys fragment
D not possible to get lys-ser fragment

27 

K isolated

D

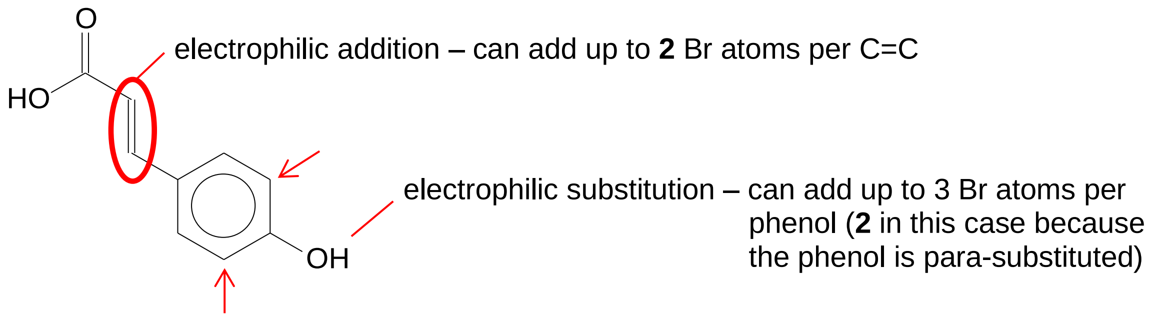
28 **A** presence of (aliphatic) aldehyde ⇒ oxidation occurs and brick–red precipitate observed **C**

B presence of C=C bond ⇒ mild oxidation occurs and purple MnO_4^-/H^+ turns colourless

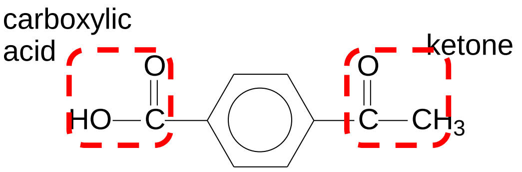
C presence of phenol ⇒ acid–base reaction occurs; both phenol and NaOH are colourless and similarly, their resulting solution [$C_6H_5O^-Na^+$(aq)].

D presence of phenol ⇒ electrophilic substitution occurs and a yellow solid formed (2–nitrophenol or 4–nitrophenol)

29 **B**



30 **B**



1 absence of (aliphatic) aldehyde ⇒ no brick–red precipitate observed

2 presence of ketone ⇒ orange precipitate observed

31 electronic configuration of S in its ground state: [Ne] $3s^2$ $3p^4$ (**2 unpaired electrons**) **B**

1 $_{22}$Ti: [Ar] $3d^2$ $4s^2$ (**2 unpaired electrons**)

2 $_{28}$Ni: [Ar] $3d^8$ $4s^2$ (**2 unpaired electrons**)

3 $_{27}$Co: [Ar] $3d^7$ $4s^2$ (3 unpaired electrons)

32 **1** NH_3 is the base while NH_4^+ is its conjugate acid. **B**

2 A <u>conjugate acid/base pair</u> contains the <u>same number of electrons</u> because they differ only by an H^+ ion (no electron).
<u>Or</u> NH_3 accepts an H^+ ion (no electron) to give NH_4^+.

3 <u>Absence of lone pair of electrons</u> in NH_4^+ ⇒ cannot act as a ligand.

33 **ΔH_{sol} = – L.E. + ΔH_{hyd} of M^{2+} + ΔH_{hyd} of SO_4^{2-}** **B**

From the equation, you can then conclude that the explanation is independent of the sum of first and second ionisation energies.

34 **1** H_2(g) should be at **298 K** (not 273 K) and 101 kPa. **B**

2 [H^+] should be at a concentration of 1.0 mol dm^{-3} (standard conditions). Therefore, the [H_2SO_4] should be 0.5 mol dm^{-3}, not 1.0 mol dm^{-3}.

3 Pt, coated with finely divided platinum, is correctly used.

35 **2** Scandium only forms 1 oxidation state (+3). **D**

3 Absence of d orbital e in Sc^{3+} ⇒ solution containing Sc^{3+} is colourless.

36 Element X is arsenic (Group V) – use your knowledge of phosphorus to predict properties of element X. **A**

1 Phosphrous forms 2 chlorides – PCl_5 and PCl_3.
2 Phosphrous forms 2 oxides – P_4O_6 (P_2O_3) and P_4O_{10}.
3 Both P_4O_6 and P_4O_{10} are acidic and react with alkali to form a hydrogen phosphite (HPO_3^{2-}) and phsophate (PO_4^{3-}) salt respectively.

37 **1** Nucleophilic substitution occurs. **A**
2 Nucleophilic substitution occurs.
3 Elimination occurs

38 A catalytic converter is able to oxidise unburnt hydrocarbons and carbon monoxide to carbon dioxide (CO_2) while reducing oxides of nitrogen (NOx) to nitrogen (N_2). **B**

39 **1** no hydrogen bonding (an intermolecular forces). **C**
2 hydrogen bonding between peptide linkages (–CONH–) along the polypeptide chain.
3 hydrogen bonding between polar R groups with >NH or –OH present.

40 **1** molecular formula of E is $(HO–C_6H_4–N)_2$ [≡ $C_{12}H_{10}O_2N_2$]. **A**
∴ empirical formula of E is C_6H_5ON, which is also the molecular and empirical formulae of G (C_6H_5NO).
2 molecular formula of F is $C_{12}N_2H_{10}O_2$.
∴ E and F are structural isomers.
3 Since the molecular formula of F and G are $C_{12}N_2H_{10}O_2$ and C_6H_5NO respectively, M_r of F is twice that of G.