NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/01**
Paper 1 Multiple Choice **15 September 2022**
1 hour

Additional Materials: Optical Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.
There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Instructions on how to fill in the Optical Mark Sheet
Shade the index number in a 5 digit format on the optical mark sheet:
2nd digit and the last 4 digits of the Registration Number.

Example:

Student	Examples of Registration No.	Shade:
	2105648	**15648**

This document consists of **15** printed pages and **1** blank page.

Suggestion solution for P1 (MCQ)

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

1 Technetium (Tc) is a second row transition element that does not occur naturally on Earth. One of its isotopes has 56 neutrons.

What is the nucleon number of this isotope?

A 43 **B** 56 **C** 99 **D** 112

Ans: **C**

Refer to Periodic Table.
Tc has atomic number 43, i.e. proton number = 43
nucleon number = proton + neutron = 43 + 56 = 99

2 Which row has the greater number of particles?

A 1 mol of liquid sulfuric acid

B 12000 cm^3 of oxygen gas at s.t.p.

C 32.5 g of zinc

D 16 g of nitrogen gas

Ans: **A**

1 mol of liquid sulfuric acid has 6.02×10^{-23} particles. There is no dissociation as the sulfuric acid is in liquid form.

12000 cm^3 of oxygen gas at s.t.p has $\frac{12000}{22700}$ = 0.5286 moles = 3.18×10^{-23} particles

32.5g of Zinc has $\frac{32.5}{65.4}$ = 0.4969 moles = 2.99×10^{-23} particles

16 g of nitrogen gas has $\frac{16}{28}$ = 0.5714 moles = 3.44×10^{-23} particles

3 Which species will have the smallest deflection when passed through the same electric field?

A $^{23}Na^+$ **B** $^{11}B^{3+}$ **C** $^{19}F^-$ **D** $^{32}S^{2-}$

Ans: **A**

Angle of deflection, $\theta \propto \frac{charge}{mass}$
The species with the smallest charge to mass ratio will have the smallest deflection.

$^{23}Na^+$: $\frac{+1}{23}$

$^{11}B^{3+}$: $\frac{+3}{11}$

$^{19}F^-$: $\frac{-1}{19}$

$^{32}S^{2-}$: $\frac{-2}{32} = \frac{-1}{16}$

4 0.0353 g of a sample of volatile organic compound was completely vaporized at 50 kPa and 300K. The vapour occupied a volume of 40 cm^3. On complete combustion in excess oxygen, 80 cm^3 of carbon dioxide and 80 cm^3 of water vapour were formed. All gaseous volumes were measured under identical conditions.

What would be the molecular formula of the compound?

A C_2H_2O **B** C_2H_4O **C** C_2H_6O **D** C_3H_8

Ans: **B**

Using $M_r = mRT/PV$: M_r = 44.0
where m = 0.0353 g, T = 300 K, $p = 50 \times 10^3$ Pa, $V = 40 \times 10^{-6}$ m^3,
R = 8.31 J K^{-1} mol^{-1}

From CO_2(g) evolved:
No. of moles of C = 80cm^3 /40cm^3 = 2 mol
Mass of C = 12.0 × 2 = 24.0 g

From H_2O(g) produced
No. of moles of H = (80cm^3/40cm^3) × 2 = 4 mol
Mass of H = 1.0 × 4 = 4.0 g

Mass of oxygen = 44 – 24 – 4 = 16.0 g

For **A**, M_r = 42.0 g
For **B**, M_r = 44.0 g (2 carbon, 4 hydrogen and 1 oxygen atom)
For **C,** M_r = 46.0 g
For **D**, M_r = 44.0 g

5 Which species has the most number of unpaired electrons?

A Co^{2+} **B** N **C** Fe **D** S

Ans: **C**

	electronic configuration	unpaired electrons	box diagram
Co^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$	3	3d: ↑↓ ↑↓ ↑ ↑ ↑
N	$1s^2 2s^2 2p^3$	3	2p: ↑ ↑ ↑
Fe	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$	4	3d: ↑↓ ↑ ↑ ↑ ↑
S	$1s^2 2s^2 2p^4$	2	2p: ↑↓ ↑ ↑

6 Rubidium and bromine form ions that are isoelectronic.

1 Ionic radius of rubidium is smaller than its atomic radius.

2 Ionic radius of bromine is larger than its atomic radius.

3 Ionic radius of bromine is smaller than that of rubidium.

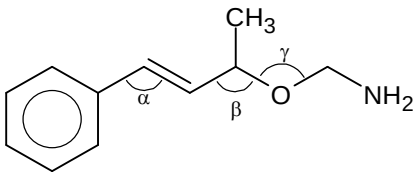
Which statements are correct?

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

Ans: **B**

	Proton number	Ion	
Rb	37	Rb^+	For Rb vs Rb^+, since the same nuclear charge is attracting less electrons for the ion, the outermost electrons are more tightly held in Rb^+ Ionic radius is smaller. Option 1 is true.
Br	35	Br^-	For Br vs Br^-, since the same nuclear charge is attracting more electrons for the ion, the outermost electrons are less tightly held in Br^- Ionic radius is larger. Option 2 is true.
			For Br^- vs Rb^+, there are less nuclear charge (less protons) attracting the same number of electrons in Br^- than in Rb^+, the outermost electrons are less tightly held by nucleus in Br^-. Ionic radius of Br^- is larger. Option 3 is not true.

7 Which row correctly shows the bond angles for α, β, γ in the molecule below?



	α	β	γ
A	109.5°	120°	109.5°
B	120°	109.5°	107°
C	120°	107°	105°
D	120°	109.5°	105°

Ans: **D**

α: 3 Bond pairs (1 C=C, 1 C-C and 1 C-H) – Bond Angle of 120°
β: 4 bond pairs (3 C-C and 1 C–H) – Bond Angle of 109.5°
γ: 2 lone pairs & 2 bond pairs (2 C–O) – Bond Angle of 105°

8 In which pair is the melting point of the **second** species higher than that of the **first** species?

A C and Si

B K and Rb

C NaC*l* and NaBr

D $SiCl_4$ and SiO_2

Ans: **D**

C and Si are both giant covalent structure and atoms held by covalent bonds. C atoms have a smaller orbital size than Si and hence greater degree of orbital overlap leader to stronger covalent bonds in C than Si. More energy is needed to break the stronger covalent bonds in C than Si. Hence, C has a higher melting point than Si.

K and Rb are both metallic lattices. Both K and Rb contribute the same number of electrons to the sea of mobile electrons. K^+ has a larger charge to size ratio than Rb^+ due to having a smaller ionic radius. More energy is needed to break the stronger metallic bonds in K than in Rb. Hence, K has a higher melting point than Si.

NaC*l* and NaBr are both giant ionic lattices. The product of the charges are the same for both NaC*l* and NaBr, however, the interionic distance for NaC*l* is smaller than NaBr. Since $\mathrm{L.E} \propto \left|\frac{q_+ \times q_-}{r_+ + r_-}\right|$, more energy is needed to break the stronger ionic bonds in NaC*l* than NaBr. Hence, NaC*l* has a higher melting point than NaBr.

$SiCl_4$ is simple molecular structure and SiO_2 is giant covalent lattice structure. More energy is needed to overcome the covalent bonds in SiO_2 than the weak id-id in $SiCl_4$. Hence, SiO_2 has a higher melting point than $SiCl_4$.

9 When liquid N_2F_4 is heated, it decomposes into a single product, **B**.

Which statements are correct?

1 N–F bonds are broken during this decomposition.

2 The enthalpy change when N_2F_4 decomposes into **B** is approximately +160 kJ mol^{-1}.

3 Molecules of **B** are non-linear.

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

Ans: **C**

$N_2F_4 \rightarrow 2NF_2$

From the equation, can see that only N-N bonds are broken. Hence statement 1 is incorrect.
Based on Data Booklet, N–N bond is +160 kJ mol^{-1}, so statement 2 is correct because that is the only bond broken in the reaction.
Statement 3 is correct because there are lone pair(s) on N of NF_2 molecule, so it has to be non-linear.

10 Three experiments were carried out involving acids and alkalis of the same concentration. The temperature changes were recorded as shown in the table below.

Volumes of acids and alkalis added together	ΔT/ ^oC
25.0 cm^3 of HC*l*(aq) + 25.0 cm^3 of NaOH(aq)	ΔT_1
50.0 cm^3 of HC*l*(aq) + 50.0 cm^3 of NaOH(aq)	ΔT_2
25.0 cm^3 of HC*l*(aq) + 25.0 cm^3 of NH_3(aq)	ΔT_3

Which row shows the correct relative magnitude of ΔT values?

A $\Delta T_2 > \Delta T_3 > T_1$ **B** $\Delta T_1 = \Delta T_2 > \Delta T_3$ **C** $\Delta T_2 = \Delta T_3 > \Delta T_1$ **D** $\Delta T_1 = \Delta T_2 = \Delta T_3$

Ans: **B**

Assuming the concentration of both acid and alkali are 1 mol dm^{-3}.
(i) 25.0 cm^3 of HC*l*(aq) + 25.0 cm^3 of NaOH(aq): 0.025 mol of H_2O produced, m = 50.0.
(ii) 50.0 cm^3 of HC*l*(aq) + 50.0 cm^3 of NaOH(aq): 0.05 mol of H_2O produced, m = 100.0.
(iii) 25.0 cm^3 of HC*l*(aq) + 25.0 cm^3 of NH_3(aq): 0.025 mol of H_2O produced, m = 50.0.

Given $\Delta T = \frac{\Delta H \times n_{H_2O}}{mc}$ and both c and ΔH_{neu} of strong acid and strong alkali are constant,
$\Delta T \propto \frac{n_{H_2O}}{m}$
Hence, $\Delta T_1 = \Delta T_2$

Magnitude of ΔH_{neu} of strong acid and weak alkali < ΔH_{neu} of strong acid and strong alkali
Hence, $\Delta T_1 = \Delta T_2 > \Delta T_3$

11 Some ΔH values are given below.

	enthalpy change of formation / kJ mol^{-1}
Fe_2O_3	– 824.2
CO	– 110.5
CO_2	– 393.5

In the industrial production of iron, iron(III) oxide is reduced by carbon monoxide.

What is the enthalpy change of reaction for one mole of iron formed?

A – 24.8 kJ mol^{-1}

B + 24.8 kJ mol^{-1}

C – 12.3 kJ mol^{-1}

D + 541.2 kJ mol^{-1}

Ans: **A**

Fe_2O_3 (s) + 3 CO (s) → 2 Fe (s) + 3 CO_2 (g)

$\Delta H_{rxn} = \sum \Delta H_{\text{formation of products}} - \sum \Delta H_{\text{formation of reactants}}$

= 3(–393.5) – [–824.2 + 3(–110.5)]

= – 24.6 kJ mol^{-1}

Hence, enthalpy change of reaction for one mole of iron formed = 24.6 ÷2 = 12.3 kJ mol^{-1}

12 Nitrogen and hydrogen form ammonia in an exothermic reaction. The rate and yield of the reaction can be altered by changing the experimental conditions.

Which row correctly describes the effect of the changes in condition?

	change in condition	effects		
		equilibrium yield	rate of forward reaction	rate of backward reaction
1	increasing temperature	decreases	increases	increases
2	increasing temperature	increases	decreases	increases
3	addition of catalyst	increases	increases	no effect
4	addition of catalyst	no effect	increases	increases

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

Ans: **A (Option 1 and 4 are correct)**

	effects	
Change in condition	equilibrium yield	Rates of forward and back reaction
increasing temperature	Eqm shifts to remove some heat, favouring backward endothermic reaction. Hence yield decreases	At higher temperature, K.E. of reactant particles increase. There is a greater proportion of particles with energy greater than activation energy for both forward and backward reactions. Hence both rate of both forward and backward reactions increase.
addition of catalyst	Increases rate of reaction, allowing eqm to be reached faster. No change in yield.	Lower activation energy for both forward and backward reactions. Both rate of both forward and backward reactions increase.

13 Four solutions, each of concentration 0.1 mol dm^{-3}, were tested with a pH meter. The results are shown.

solution	pH
CH_3CO_2H	4
HNO_3	1
CH_3NH_2	11
NaOH	14

Which statement is **incorrect**?

A Conjugate base of CH_3CO_2H is less stable than that of HNO_3.

B HNO_3 has a lower pH than CH_3CO_2H because it is more soluble.

C NaOH has a higher concentration of hydroxide ions in solution than CH_3NH_2.

D Mixing equal volume of CH_3NH_2 and HNO_3 form a solution with pH less than 7.

Ans: **B**

Option A: Correct
HNO_3 and CH_3CO_2H are of same concentration. Given that CH_3CO_2H has pH 4, implies that there is less dissociation for CH_3CO_2H. i.e. Conjugate base of CH_3CO_2H is less stable than that of HNO_3.

Option B: Incorrect
HNO_3 has a lower pH than CH_3CO_2H **because** HNO_3 dissociates fully while CH_3CO_2H partially dissociates.

Option C: Correct
NaOH has a higher concentration of hydroxide ions in solution than CH_3NH_2, hence NaOH has a higher pH.

Option D: Correct
Mixing equal volumes of CH_3NH_2 and HNO_3 gives salt $CH_3NH_3^+NO_3^-$ only.
$CH_3NH_2 + HNO_3 \rightarrow CH_3NH_3^+NO_3^-$

$CH_3NH_3^+NO_3^-$ dissociates to give $CH_3NH_3^+$ and NO_3^-
$CH_3NH_3^+$, conjugate acid of CH_3NH_2, undergoes hydrolysis to give H_3O^+, hence pH < 7.

$CH_3NH_3^+ + H_2O \rightleftharpoons CH_3NH_2 + H_3O^+$

14 Solid calcium hypochlorite pellets, $Ca(ClO)_2(s)$, are added to swimming pools to form $HClO(aq)$ which kills disease-causing bacteria and algae.

$$Ca(ClO)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2ClO^-(aq)$$

$$ClO^-(aq) + H_2O(l) \rightleftharpoons HClO(aq) + OH^-(aq)$$

What is the effect on the solubility of calcium hypochlorite and bacterial growth when pH increases?

	effect on solubility of calcium hypochlorite	effect on bacterial growth
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

Ans: **A**

$Ca(ClO)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2ClO^-(aq)$ --- Eqm 1

$ClO^-(aq) + H_2O(l) \rightleftharpoons HClO(aq) + OH^-(aq)$ --- Eqm 2

When pH increases, $[OH^-]$ increases. Position of equilibrium in eqm 2 shifts left leading to an increase in $[ClO^-]$ which in turn causes the position of equilibrium in eqm 1 to shift left. Solubility of calcium hypochlorite decreases. $[HClO]$ that kills bacteria also decreases and hence bacterial growth increases.

15 A mixture of two oxides of period 3 elements is added to water and the resultant solution has a pH value below 7.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

Ans: D

A Al_2O_3 insoluble in water and MgO sparingly soluble in water: hence pH slightly > 7

B Na_2O gives NaOH in water and MgO sparingly soluble in water: hence pH > 7

$Na_2O + H_2O \rightarrow 2NaOH$

C Na_2O (gives NaOH in water) and P_4O_{10} (gives H_3PO_4 in water)

$H_3PO_4 + NaOH \rightarrow Na_3PO_4 + 3H_2O$

PO_4^{3-}, conjugate base of H_3PO_4, undergoes hydrolysis to give OH^-, hence pH > 7.

$PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$

D SO_3 (gives H_2SO_4 in water) and P_4O_{10} (gives H_3PO_4 in water), hence pH < 7.

16 Anhydrous magnesium nitrate, $Mg(NO_3)_2$, decomposes when heated, giving a white solid and a mixture of two gases, **D** and **E**. **E** is oxygen.

What is the ratio of $\frac{\text{mass of D released}}{\text{mass of E released}}$?

A $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

Ans: **A**

Thermal decomposition: $Mg(NO_3)_2\ (s) \rightarrow MgO(s) + 2NO_2(g) + \frac{1}{2}\ O_2(g)$
Mass of E = ½ (32.0) = 16.0 g
Mass of D = 2 (46.0) =92.0 g

Ratio of $\frac{\text{mass of D released}}{\text{mass of E released}} = \frac{92}{16} = \frac{92/92}{16/92} = \frac{1}{16/92} = \frac{1}{0.174}$

17 Addition of warm concentrated sulfuric acid, H_2SO_4, to crystals of sodium halides gives the following observations.

compound	observation
NaF	evolution of a colourless gas which etches a damp glass rod
NaC*l*	evolution of a choking colourless gas which produces a white cloud in contact with ammonia vapour
NaBr	evolution of a brown vapour and of pungent fumes which turn potassium dichromate(VI) paper green
NaI	evolution of a purple vapour and a gas smelling of rotten eggs

Which statements are consistent with the observations?

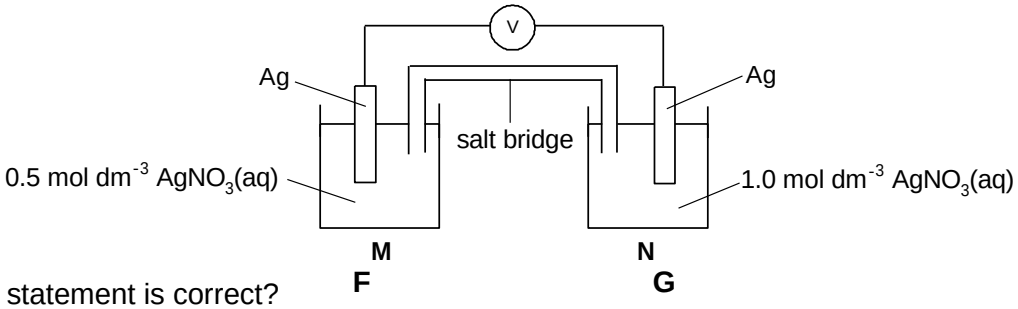
	hydrogen halide is produced in all four reactions	H_2SO_4 is acting as a reducing agent in all four reactions	SO_2 and H_2S are reduction products of H_2SO_4
A	true	false	true
B	true	true	false
C	false	false	true
D	false	true	false

Ans: C

compound	observation
NaF	evolution of a colourless gas (HF) which etches a damp glass rod
NaC*l*	evolution of a choking colourless gas (HC*l*) which produces a white cloud in contact with ammonia vapour
NaBr	evolution of a brown vapour **(Br_2)** and of pungent fumes **(SO_2)** which turn potassium dichromate(VI) paper green
NaI	evolution of a purple vapour **(I_2)** and a gas smelling of rotten eggs **(H_2S)**

hydrogen halide is produced in all four reactions	H_2SO_4 is acting as a reducing agent in all four reactions	SO_2 and H_2S are reduction products of H_2SO_4
Not true. HX produced for NaF and NaC*l*	Not true. For NaF and NaC*l*, HX gas is produced. Hence no change in oxidation state of F and C*l*	True. SO_2 and H_2S are reduction products as seen for compounds NaBr and NaI.

18 The following electrochemical cell was set up and the E_{cell} value was found to be +0.018 V.



Which statement is correct?

A Electrode potential of $AgNO_3$ / Ag electrode in half-cell **F** is found to be – 0.782V.

B The E_{cell} value becomes less positive when solid sodium chloride is added to half–cell **F**.

C The E_{cell} value becomes 0.00 V by adding concentrated ammonia gradually to $AgNO_3$ in half-cell **G**.

D The change in the magnitude of the E_{cell} value is the same when same number of moles of iodide or bromide is added to half-cell **G** separately.

Ans: **C**

Option A: Incorrect

From *Data Booklet*:

Half-cell **G**: $Ag^+ + e^- \rightleftharpoons Ag$ $\quad E^\ominus (Ag^+|Ag) = +0.80$ V …..(1)

Half-cell **F**: $Ag \rightleftharpoons Ag^+ + e^-$ $\quad E_{ox} (Ag\,|Ag^+) = ?$ V …..(2)

$E_{cell} = E^\ominus (Ag^+|Ag) + E_{ox}(Ag|Ag^+)$

$0.018 = (+0.80) + E_{ox}(Ag|Ag^+)$

$E_{ox} (Ag|Ag^+) = – 0.782$ V

$E (Ag^+|Ag) = – E_{ox}(Ag|Ag^+) = +0.782$ V

Option B: Incorrect

Addition of NaC*l* decrease $[Ag^+]$ in half-cell **F** due to formation of AgC*l*. By LCP, eqm position of (2) shifts right to partially offset the decrease in $[Ag^+]$, **favouring oxidation**.

E_{ox} (Ag|Ag+) for half-cell F become more positive and E_{cell} value becomes more positive.

$E_{cell} = E^\ominus (Ag^+|Ag) + E_{ox}(Ag|Ag^+)$

Option C: Correct

Gradual addition of concentration ammonia decreases $[Ag^+]$ in half-cell **G** due to formation of $[Ag(NH_3)_2]^+$. By LCP, eqm position of (1) shifts left to partially offset the decrease in $[Ag^+]$. $E(Ag^+|Ag)$ **for half-cell G** become less positive until $E (Ag^+|Ag) = +0.782$ V, and E_{cell} becomes 0.00 V.

Option D: Incorrect

Addition of iodide and bromide decrease $[Ag^+]$ in half-cell **G** due to formation of AgI and AgBr. By LCP, eqm position of (1) shifts left to partially offset the decrease in $[Ag^+]$.

$E (Ag^+|Ag)$ **for half-cell G** become less positive and E_{cell} decreases.

However, K_{sp} of AgI is lower than that of AgBr, this resulted $[Ag^+]$ to decease differently, hence the change in the magnitude of E_{cell} value will also be different.

19 Which statement about the anodising of aluminium using dilute sulfuric acid is correct?

A Water is reduced at the cathode.

B Oxygen is produced at the cathode.

C The A*l* object to be anodised is the negative electrode.

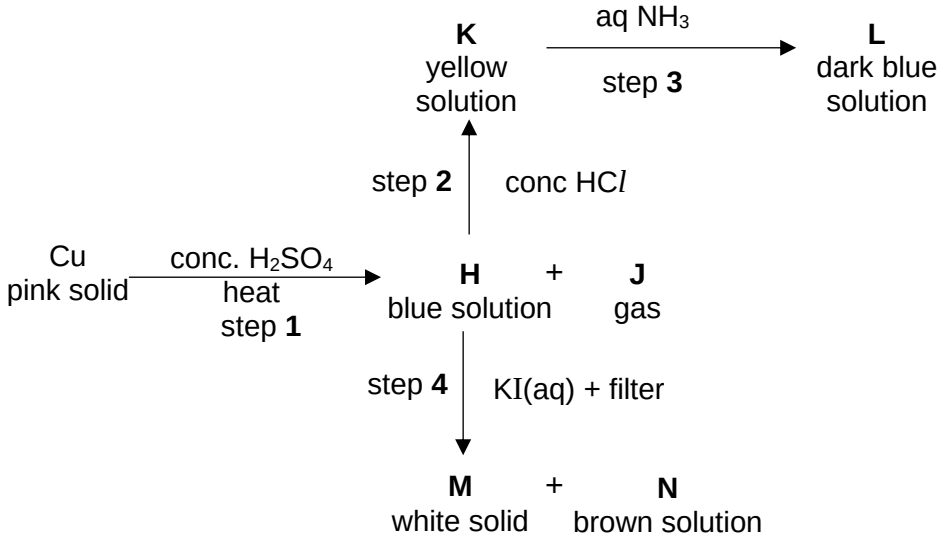
D The mass of the anode increases.

Ans: **D**

The aluminium object to be anodised is the anode that is connected to the positive terminal of the battery. The aluminium object is the positive electrode.

During anodisation, H^+ is reduced at the cathode to produce H_2 while H_2O is oxidised at the anode to produce O_2 which increase the thickness of the Al_2O_3 layer on the surface of the aluminium object. Hence mass of anode increased.

20 Consider the following reaction scheme.



Which statement is correct?

A $[Cu(OH)_4]^{2-}$ is the dark blue complex in **L**.

B Infinite dilution of solution **K** gives a pale yellow solution.

C Cation in compounds **K** and **M** has the same oxidation state.

D Step 4 involves both redox and precipitation reactions.

Ans: **D**

step 1: $Cu(s) + 2H_2SO_4(l) \rightarrow CuSO_4(aq) + SO_2(g) + 2H_2O(l)$ (redox reaction)

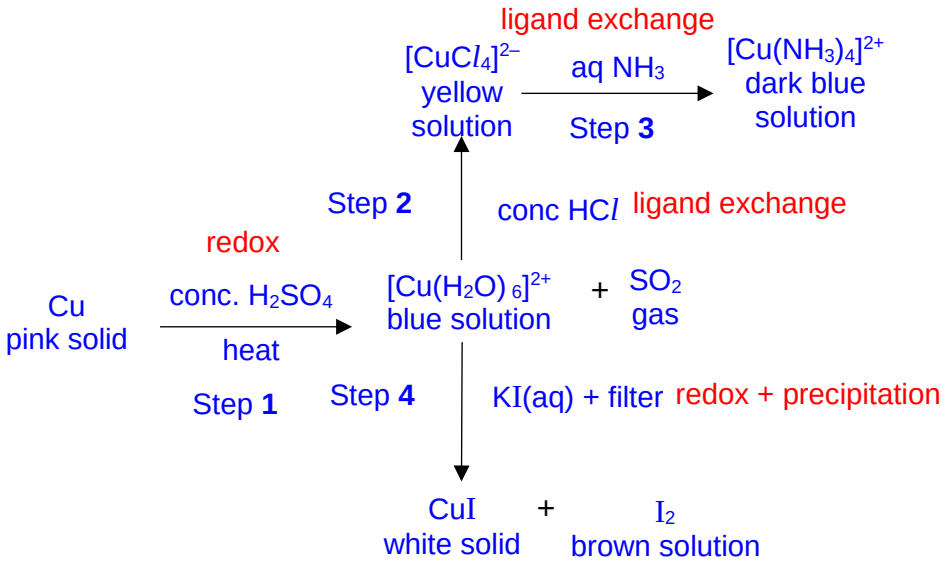
step 2: $[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6H_2O(l)$ (ligand exchange)

(+2)

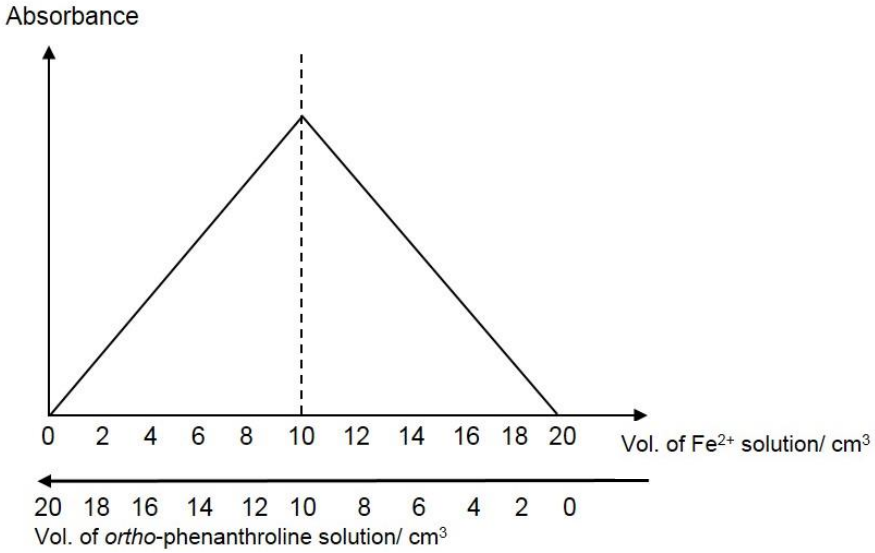
step 3: $[CuCl_4]^{2-}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+} + 4Cl^-(aq)$ (ligand exchange)

step 4: $2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI\ (s) + I_2(aq)$ (redox + precipitation)

(+1)



21 Fe^{2+} ion forms a red octahedral complex with *ortho*-phenanthroline molecules. Various samples containing different volumes of 1×10^{-5} mol dm^{-3} Fe^{2+} and 3×10^{-5} mol dm^{-3} *ortho*-phenanthroline were prepared. The following graph was obtained when the colour intensity of the samples was measured using a colorimeter.



Which statement about the complex ion is correct?

A The complex ion absorbs red light.

B The overall charge of the complex ion is –4.

C The co-ordination number of the Fe^{2+} ion is 3.

D *Ortho*-phenanthroline is a bidentate ligand.

Ans: **D**

Mole ratio of Fe^{2+} and ortho-phenanthroline is 1:3 (1×10^{-7} mol : 3×10^{-7} mol)

1 mole of Fe^{2+} combined with 3 mole of ortho-penanthroline to form complex ion. Since there are 3 ligands and the coordination no. of Fe^{2+} is 6 as it forms octahedral complex, ortho-penanthroline is a bidentate ligand.

Ortho-penanthroline molecule has no charge, hence, the overall charge of the complex ion has the same charge as Fe^{2+}.

The colour observed is the complementary colour of the wavelength of light absorbed. Since the colour of complex ion is red, the wavelength of light absorbed is not red light.

22 One molecule of dodecane, $C_{12}H_{26}$, is cracked to produce three products, **R**, **S** and **T**. **R** is a straight chain alkane. **S** and **T** are straight chain alkenes with different M_r values.

Which statements about **R**, **S** and **T** are correct?

1 If **S** and **T** are but-1-ene and ethene respectively, **R** will be hexane.

2 If **R** is butane, only one, either **S** or **T**, exhibits cis-trans isomerism.

3 **R** could be octane.

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

Ans: B

1 If **S** and **T** are but-1-ene and ethene respectively, **R** will be hexane. **True.**

$C_{12}H_{26} \rightarrow C_4H_8 + C_2H_4 + \mathbf{R}$

S **T**

R = $C_{(12-4-2)}H_{(26-8-4)} = C_6H_{14}$

2 If **R** is butane, only one, either **S** or **T**, exhibits cis-trans isomerism. **True.**

$C_{12}H_{26} \rightarrow C_4H_{10} + \mathbf{S} + \mathbf{T}$

R

S + R = 8 carbons + 16 hydrogens

Given that **S** and **T** are straight chain alkenes with different M_r values, **S** and **T** cannot be C_4H_8.

S and T is C_2H_4 (no cis-trans) + C_6H_{12} (cis-trans) or C_3H_6 (no cis-trans) +C_5H_{10} (cis-trans).

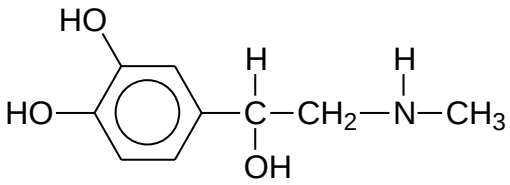
3 **R** could be octane. NOT **True.**

$C_{12}H_{26} \rightarrow C_8H_{18} + \mathbf{S} + \mathbf{T}$

R

If **R** is octane, **S** + **T** = 4 carbons + 8 hydrogens
Given that **S** and **T** are straight chain alkenes with different M_r values, hence **R** cannot be octane.

23 Adrenalin is a stimulant produced in the adrenal glands. It has the following structure.



Which statement about adrenalin is correct?

A One mole of adrenalin can only react with one mole of ethanoyl chloride.

B One mole of adrenalin reacts with two moles of hydrogen chloride.

C It gives effervescence with potassium carbonate.

D It reacts with ethanoic acid to form amide.

Ans: B

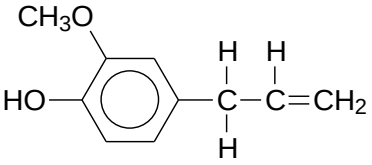
Option A:
Lone pair electrons on O atom of OH group and N atom of amine group in Adrenalin could undergo nucleophilic acyl substitution reaction with ethanoyl chloride. With three OH groups and one amine group, one mole of adrenalin could react with four moles of ethanoyl chloride.

Option B:
HC*l* undergo nucleophilic substitution with secondary alcohol of Adrenalin(but not phenol due to C-O bond of phenol has double bond character which is very difficult to break) to form halogen compound. HC*l* undergoes acid base reaction with amine group in adrenalin to form salt. Hence, one mole of adrenalin could react with two moles of hydrogen chloride.

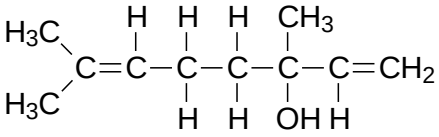
Option C:
Carboxylic acid, a stronger acid than phenol, can react with carbonate, but phenol does not react with carbonate. No effervescence is observed with potassium carbonate.

Option D:
Amide is only formed from the reaction between acyl chloride and amine. Amine undergoes acid base reaction with carboxylic acid to form a salt.

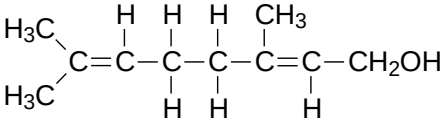
24 The following compounds are found in essential oils extracted from herbs and spices.



Eugenol



Linalool



Geraniol

Which statement is **incorrect**?

A Both Linalool and Geraniol exhibit stereoisomerism.

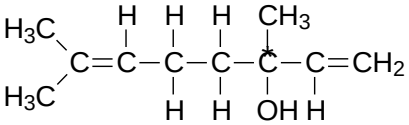
B One mole of Eugenol reacts with at least two moles of Br_2 in the absence of light.

C Linalool gives yellow precipitate with warm alkaline I_2(aq).

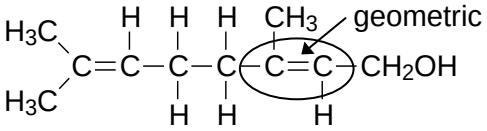
D Geraniol decolorises cold acidified $KMnO_4$.

Ans: **D**

Option A: Linalo-ol exhibits enantiomerism. Geraniol exhibits cis-trans isomerism.

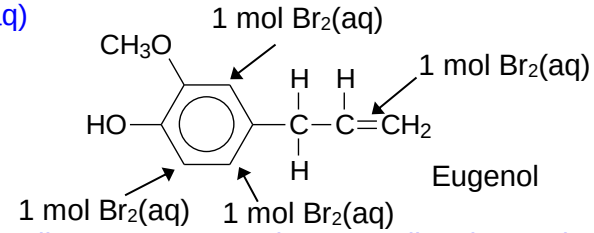


Linalo-ol



Geraniol

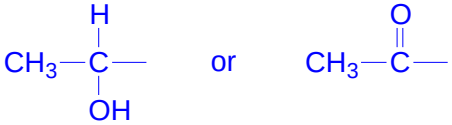
Option B: Eugenol can undergo both electrophilic substitution and electrophilic addition with Br_2(aq)



Eugenol

Note: Like – OH, $–OCH_3$ is a 2, 4 directing and strong activating group. Hence, Br_2 could undergo electrophilic substitution at 2, 4 position w.r.t $–OCH_3$. Therefore, a total of 4 moles of Br_2 can react per mole of Eugenol (Electrophilic substitution with 3 moles of Br_2 and electrophilic addition with 1 mole of Br_2.)

Option C: Linalool does not have the following structure and hence it will not give yellow ppt with iodoform test.



Option D: Each C=C bond in Geraniol undergoes mild oxidative to form diol in cold acidified $KMnO_4$. $KMnO_4$ decolourises as it is reduced to Mn^{2+} in acidic medium.

25 Which reactions of propan-1-ol produce water as a by-product?

1 passing propan-1-ol vapour over hot Al_2O_3

2 mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated H_2SO_4

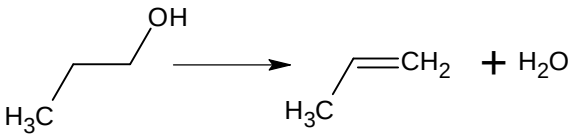
3 warming propan-1-ol with HCN

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

Ans: **B**

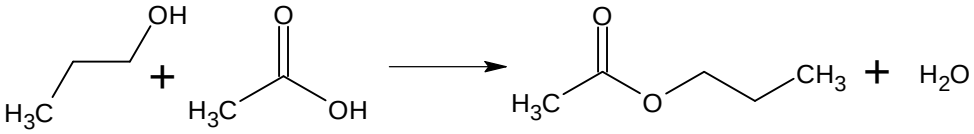
Option 1

Passing propan-1-ol vapour over hot Al_2O_3 causes it dehydration to form a C=C, giving H_2O as the by-product.



Option 2

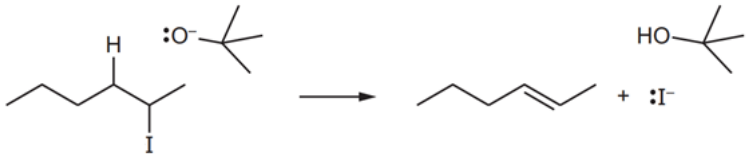
Mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated H_2SO_4 results in esterification, producing H_2O as the by-product.



Option 3

Warming propan-1-ol with HCN would not result in any reaction and HCN does not dissociate readily to give CN^- to react with the alcohol group. Neither does the alcohol group undergo nucleophilic substitution under the given conditions.

26 Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

A $(CH_3)_3CO^-$ is behaving as a Lewis base.

B $(CH_3)_3CO^-$ is behaving as an oxidising agent.

C The C–I bond breaks via homolytic fission.

D This is a nucleophilic substitution reaction.

Ans: **A**

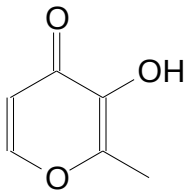
Option A (Correct)
$(CH_3)_3CO^-$ has a lone pair of electrons which is used to remove a H^+ from the starting reactant.

Option B (Incorrect)
There is no change in the oxidation state of any of the atoms.

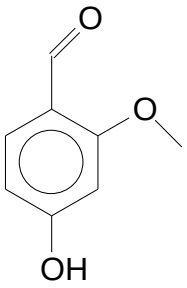
Option C (Incorrect)
The C–I bond breaks via heterolytic fission to give an I^-

Option D (Incorrect)
This is an elimination reaction in which a H^+ and I^- is eliminated to give the hex-2-ene.

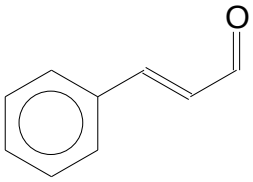
27 Maltol, vanillin and cinnamaldehyde are some naturally occurring flavouring agents.



maltol



vanillin



cinnamaldehyde

Which pair of reagents would enable the three compounds to be distinguished from one another?

	reagent 1	reagent 2
A	2,4-dinitrophenylhydrazine	hot acidified $K_2Cr_2O_7$
B	$[Ag(NH_3)_2]^+$ solution	neutral aqueous $FeCl_3$
C	Fehling's solution	hot acidified $KMnO_4$
D	anhydrous $SOCl_2$	aqueous Br_2

Ans: **B**

Option A: (Incorrect)
The aldehyde group in both vanillin and cinnamaldehyde and ketone group for maltol give orange ppt with 2,4-DNPH. The aldehyde group in both vanillin and cinnamaldehyde can be oxidised and turns orange $K_2Cr_2O_7$ to green. Thus these compounds are unable to be distinguished apart.

Option B: (Correct)
The aldehyde group in both vanillin and cinnamaldehyde formed silver mirror with Tollen's reagent ($[Ag(NH_3)_2]^+$ solution), but maltol has no aldehyde. The phenol group in vanillin give violet complex with neutral aqueous $FeCl_3$. Thus, three compounds could be distinguished apart.

Option C: (Incorrect)
Only cinnamaldehyde formed brick-red ppt with Fehling's solution (aliphatic aldehyde). In the presence of hot acidified $KMnO_4$, maltol undergoes oxidative cleavage of C=C bond, while the aldehyde group of vanillin is oxidised to form carboxylic acid. Both maltol and vanillin decolourise purple $KMnO_4$. Thus these two compounds are unable to be distinguished apart.

Option D: (Incorrect)
$SOCl_2$ has no reaction with maltol and vanillin despite both having a hydroxyl group. C–OH bond in both maltol and vanillin has a partial double bond character due to resonance and hence OH group cannot be substituted by Cl. Aqueous Br_2 decolourised in all three compounds due to presence of C=C or phenol group in each compound. Only vanillin formed white ppt. Thus, two out of three compounds could not be distinguished apart.

28 The following compounds were treated with hot acidified $KMnO_4$ (aq).

Which compound gives an organic product that is **different** from the other three?

A CH_3COCl

B $CH_3CH_2OCOCH_3$

C $CH_3CH{=}CHOH$

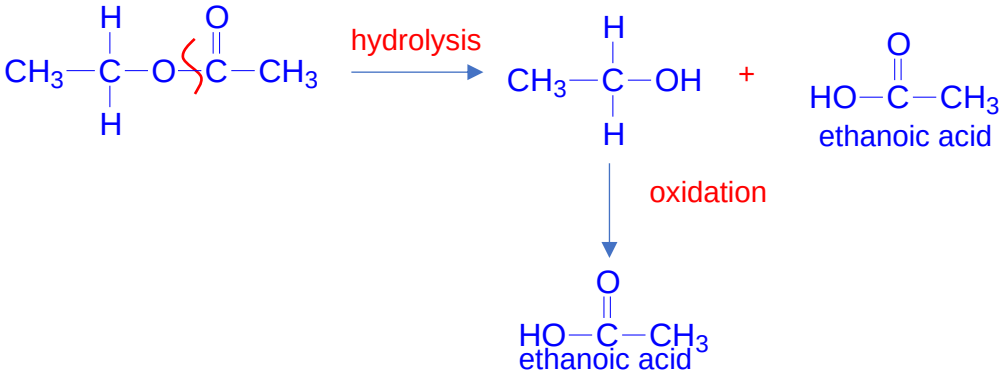
D $CH_3CH_2COOCH_3$

Ans: **D**

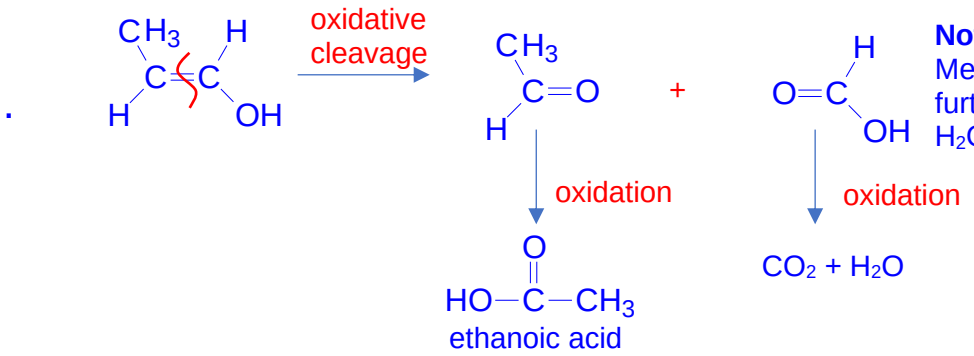
Option A: CH_3COCl undergoes hydrolysis to form ethanoic acid ***(organic product)*.**

$$CH_3COCl + H_2O \xrightarrow{\text{hydrolysis}} \underset{\text{ethanoic acid}}{CH_3CO_2H} + HCl$$

Option B: Ester undergoes hydrolysis followed by oxidation of primary alcohol to form ethanoic acid.

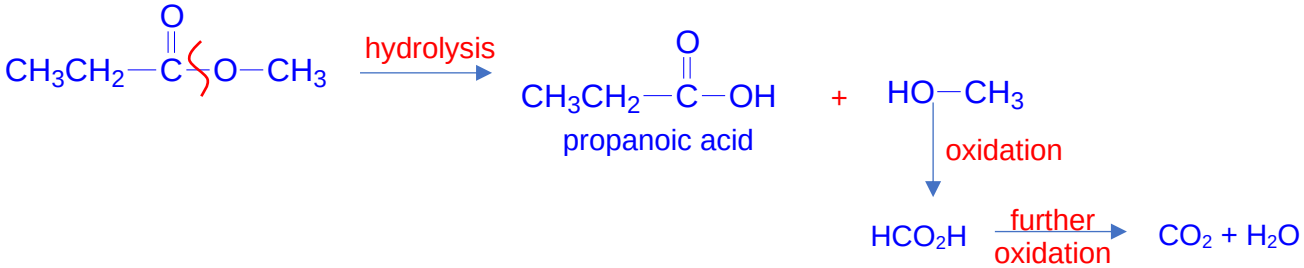


Option C: C=C bond undergoes oxidative cleavage followed by oxidation to form ethanoic acid, carbon dioxide and water.

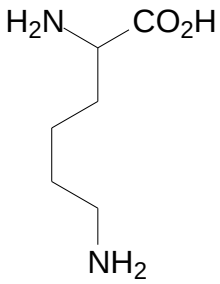


Note:
Methanoic acid, HCO_2H, can be further oxidised to form CO_2 and H_2O.

Option D: Ester undergoes hydrolysis followed by oxidation to form propanoic acid, carbon dioxide and water. It gives a different organic product, propanoic acid.



29 Amino acid **Y** has three pK_a values given below:



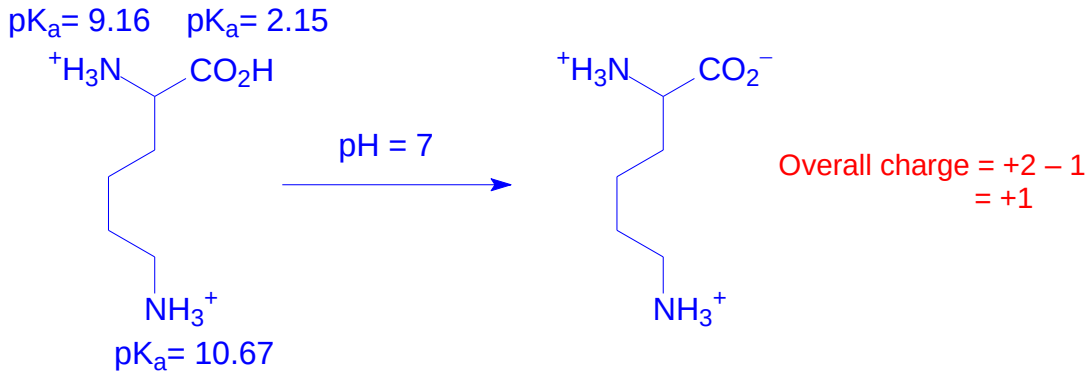
amino acid **Y**

	α-carboxyl group	α-amino group	side chain
pK_a	2.15	9.16	10.67

What is the net charge of the predominant species of amino acid **Y** at pH 7?

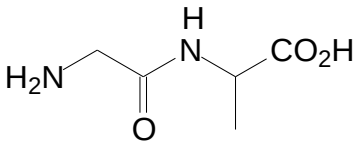
A +2 **B** +1 **C** 0 **D** –1

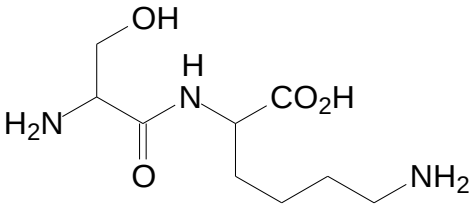
Ans: **B**

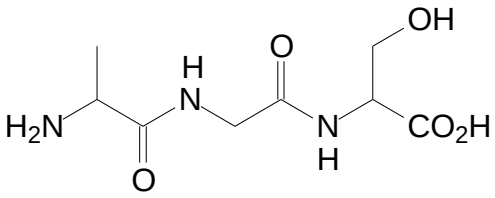


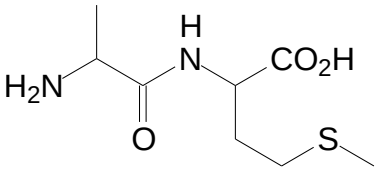
Note:
pH > pK_a, the acid group is deprotonated due to higher pH (more alkaline).
pH < pK_a, the acid group is protonated due to lower pH (more acidic)

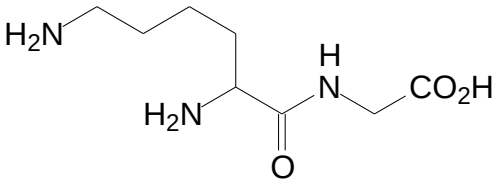
30 Heptapeptide **X** contains seven amino acid residues. When **X** is partially hydrolysed, the following dipeptide and tripeptide fragments are produced.







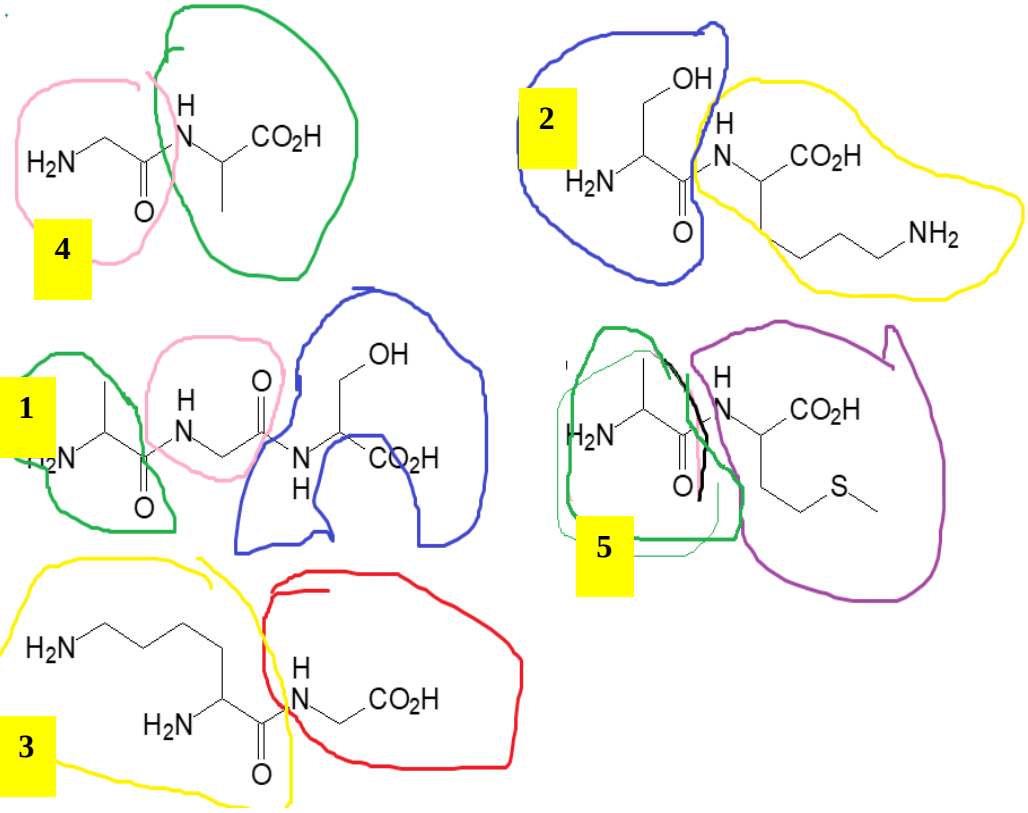




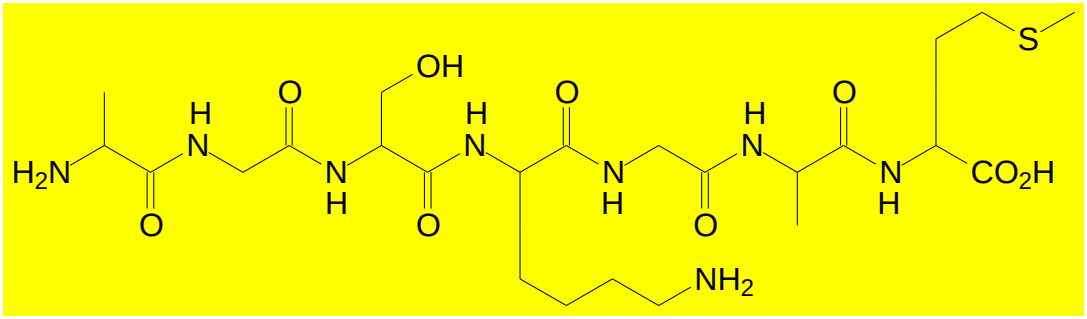
Which of the four heptapeptides on page 15 is the formula of **X**?

Ans: **A**

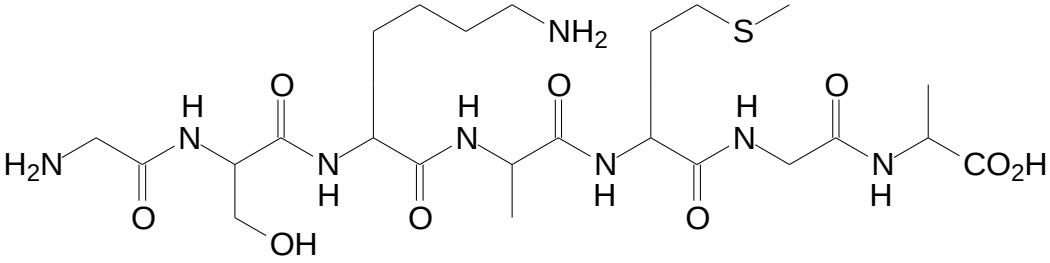
Identify the different amino acid residue by recognising the different R group attached to the alpha-carbon of the amino acid in the dipeptide and tripeptide fragments. Match the amino acid residue in the fragments to obtain the structure of the heptapeptide.



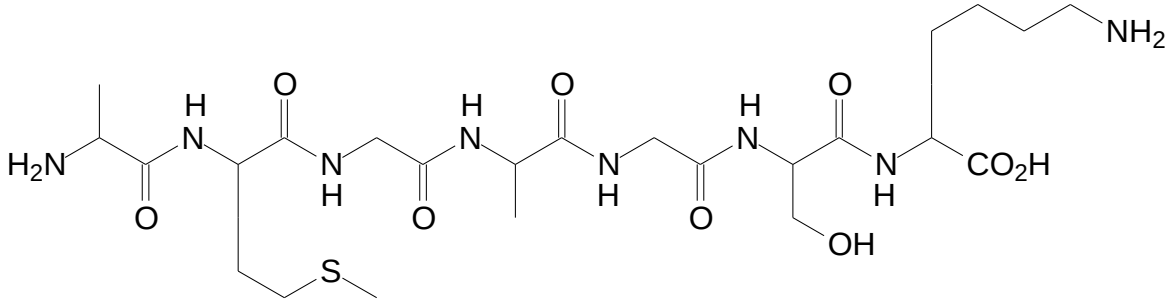
A



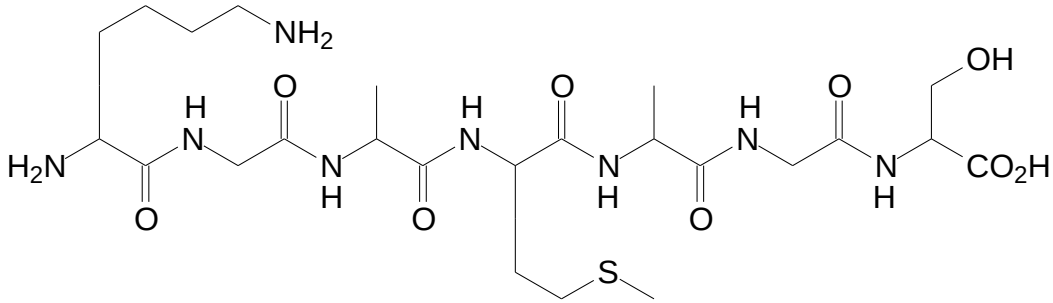
B



C



D



Suggestion solution for P1 (MCQ)

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