Class Adm No

Candidate Name: _____

H

millennia institute

2023 Preliminary Examination
Pre-University 3

H2 CHEMISTRY **9729/01**

Paper 1 Multiple Choice **20th Sep 2023**

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)	

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

Total:

A	6
B	8
C	8
D	8

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 contain the same number of hydrogen atoms?

1 0.10 mol of pentane
2 0.15 mol of but-2-ene
3 0.60 mol of hydrogen gas
4 0.50 mol of steam

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

Pentane is C_5H_{12} amt of H atoms = $0.10 \times 12 = 1.2$ mol
But-2-ene is C_4H_8 amt of H atoms = $0.15 \times 8 = 1.2$ mol
H_2 amt of H atoms = $0.60 \times 2 = 1.2$ mol
H_2O amt of H atoms = $0.5 \times 2 = 1.0$ mol
(A)

2 Ascorbic acid found in fruits and vegetables is believed to help prevent colds.

Analysis of ascorbic acid shows that it contains only carbon, hydrogen and oxygen with 40.91% carbon and 4.55% hydrogen by mass. Ascorbic acid has a molar mass of 176 g mol^{-1}.

What is the molecular formula of ascorbic acid?

A $C_2H_3O_2$

B $C_3H_4O_3$

C $C_6H_8O_6$

D $C_6H_9O_6$

Draw up the empirical formula table first

	C	H	O
% by mass	40.91	4.55	100–40.91–4.55 = 54.54
amt	40.91/12.0	4.55/1.0	54.54/16.0
	=3.409	=4.55	3.409
Simplest ratio	1 = 3	1.33 = 4	3 = 3

Empirical formula = $C_3H_4O_3$

Let molecular formula be $(C_3H_4O_3)_x$

$x\ (3\times12.0 + 4 \times 1.0 + 3 \times 16.0) = 176$

$x = 2$

Hence molecular formula is $C_6H_8O_6$.

Note: 1.33 for H should not be rounded to 1.5 because 1.33 is equivalent to 4/3 hence all values should be multiplied by 3 throughout.

(C)

3 Which of the following species is **unable** to act as a Lewis acid?

A $AlCl_3$

B $FeCl_3$

C $BeCl_2$

D CCl_4

Lewis acid is an electron pair acceptor.

CCl_4 does not have empty orbitals to accept any electron pairs.

(D)

4 In 2020, a massive explosion took place in Beirut at a warehouse which stocked ammonium nitrate. Ammonium nitrate, $\underline{N}H_4NO_3$ decomposes explosively when heated to form nitrous oxide, N_2O and water, H_2O.

What is the change in the oxidation number of the nitrogen atom that is underlined when this reaction happens?

A –2
B +1
C +3
D +4

Oxidation number of N in NH_4^+ = –3
Oxidation number of N in N_2O = +1
Change = +4
(D)

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

What do the ions $^{31}P^{3-}$ and $^{32}S^{2-}$ have in common?

A Both ions have more neutrons than protons.
B Both ions have more electrons than neutrons.
C Both ions have more protons than electrons.
D Both ions have an outer electronic configuration of $2s^2\ 2p^6$.

$^{31}P^{3-}$ has 15 protons, 16 neutrons and 18 electrons
$^{32}S^{2-}$ has 16 protons, 16 neutrons and 18 electrons
Only $^{31}P^{3-}$ has more neutrons than protons.(16 > 15) A is incorrect
Both ions have more electrons than neutrons. (18 > 16) B is correct
Both have more electrons than protons (18> 15 or 16) C is incorrect
Both P and S are in period 3 so their outer electronic configuration would be $3s^2\ 3p^6$
D is incorrect
(B)

6 The table below shows the ionisation energy (in kJ mol^{-1}) of four elements labelled **A**, **B**, **C** and **D**.

Element	1st I.E.	2nd I.E.	3rd I.E.	4th I.E.	5th I.E.	6th I.E.
A	1012	1907	2914	4964	6274	21 267
B	787	1577	3232	4356	16 091	19 805
C	1521	2666	3931	5771	7238	8781
D	738	1451	7733	10 543	13 630	18 020

Which element above has no electrons in the valence p subshell?

A element **A**

B element **B**

C element **C**

D element **D**

Look for the large jump that indicates removal of electron from the inner principal quantum shell.

Element **A** large jump between 5th and 6th ➔From group 15

Element **B** large jump between 4th and 5th ➔From group 14

Element **C** no visible large jump from first 6 electrons ➔From group 17 or 18

Element **D** large jump between 2nd and 3rd ➔From group 2 (does not have p electrons)

(D)

7 Which molecules contain at least one bond angle of 120°?

1 C_2H_4

2 PCl_5

3 NF_3

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

C_2H_4 is trigonal planar about both C atoms ➔ bond angle is 120°

PCl_5 is trigonal bipyramidal about P ➔ bond angle is 120° at the equatorial plane

NF_3 is trigonal pyramidal about N ➔ bond angle is 107°

(B)

8 Elements **E**, **F** and **G** are all in the first two periods of the Periodic Table.
Their Pauling electronegativity values, E_N, are given in the table.

element	E_N
E	1.0
F	2.5
G	3.0

Compounds exist with formulae **EG**, **FG** and **G_2**.

What is the correct order of increasing boiling point of the three compounds?

A **EG → FG → G_2**

B **EG → G_2 → FG**

C **G_2 → FG → EG**

D **G_2 → EG → FG**

EG with big difference in electronegativity ➔ ionic compound with ionic bonds
FG with small difference in electronegativity ➔ covalent compound. Polar ➔ pd–pd
G_2 with no difference in electronegativity ➔ covalent compound. Non polar ➔ id–id
G_2 lowest followed by **FG** followed by **EG** as the highest.
(C)

9 When an evacuated glass bulb of volume 300 cm^3 is filled with a gas at 450 K and 101 kPa, the mass of the bulb increases by 0.679 g. The gas obeys the ideal gas equation.

What is the identity of the gas?

A argon

B krypton

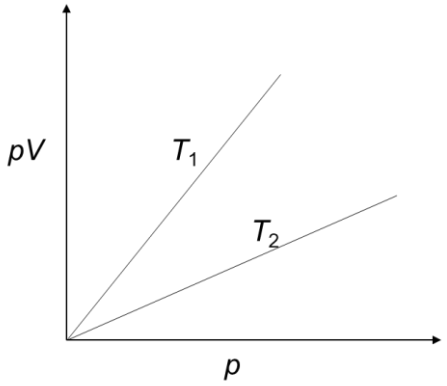
C neon

D nitrogen

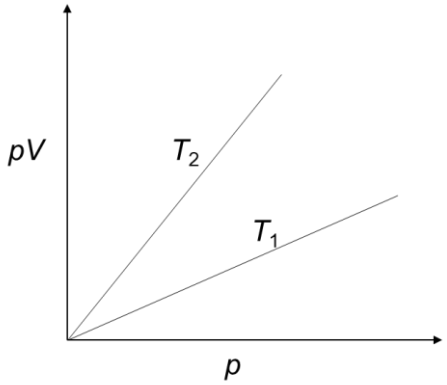
Using $pV = nRT$
$pV = (M/M_r)RT$
$M_r = MRT/pV$
$M_r = 0.679 \times 8.31 \times 450 / (101 \times 10^3 \times 300 \times 10^{-6}) = 83.8$
(B)

10 Which graph shows the correct plot of pV against p for a fixed mass of ideal gas at two temperatures, T_1 and T_2, in which $T_1 > T_2$?

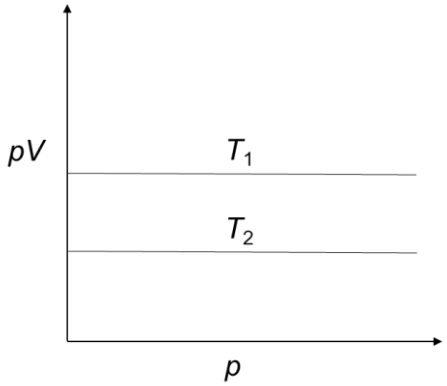
A



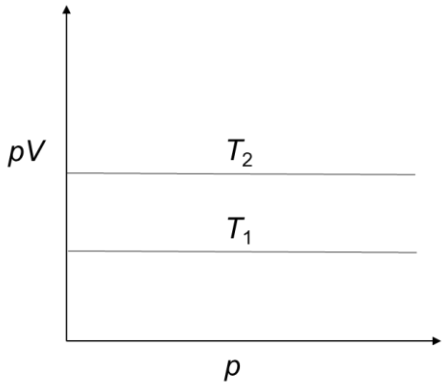
B



C



D



For a fixed mass of gas, n is constant

$pV = nRT$

for T_1 and T_2,

pV = constant x (fixed value of T)

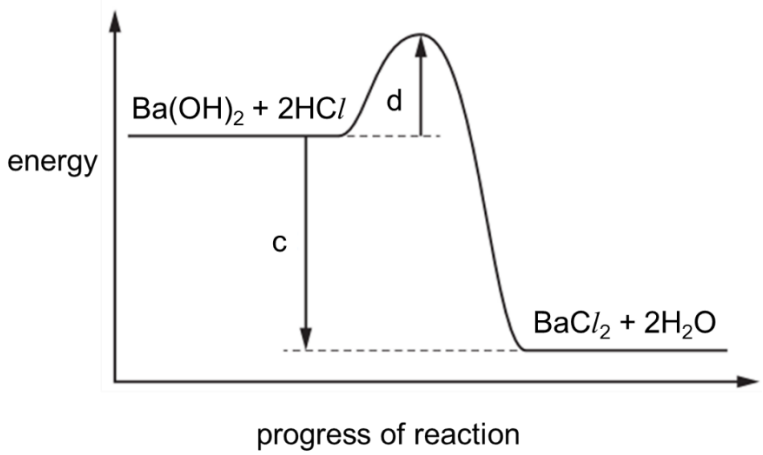
pV will be a constant for all values of p ➔ horizontal straight line

since $T_1 > T_2$ ➔ $p_1V_1 > p_2V_2$

T_1 line will be higher than T_2 line

(C)

11 A reaction pathway diagram for the reaction of aqueous barium hydroxide and dilute hydrochloric acid is shown.



What is the value of the enthalpy change of neutralisation, ΔH_{neut}?

A c **B** c – d **C** $\frac{c}{2}$ **D** $\frac{(c - d)}{2}$

c is the ΔH for the reaction and d is the activation energy so we should focus on c.

We are interested in ΔH_{neut} which is for one mole of water formed. Since the reaction forms two moles of water, the value of ΔH_{neut} will be half of c or $\frac{c}{2}$.

(C)

12 The enthalpy change of reaction, $\Delta H_r^{\ominus}$, for the following reaction is ***e*** kJ mol^{-1}.

$$2C(s) + 3H_2(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H_r^{\ominus} = \boldsymbol{e} \text{ kJ mol}^{-1}$$

What is the correct expression to calculate the value of ***e***?

A $2 \times \Delta H_c^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

B $2 \times \Delta H_c^{\ominus}[CO_2(g)] + 3 \times \Delta H_f^{\ominus}[H_2O(g)]$

C $2 \times \Delta H_f^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

D $2 \times \Delta H_f^{\ominus}[CO_2(g)] + 3 \times \Delta H_f^{\ominus}[H_2O(l)]$

Recognise that the reaction can be considered in terms of ΔH_c of reactants or ΔH_f of the products. This means we should not see ΔH_c of products or ΔH_f of the reactants (especially since the reactants are elements in their standard states) in the options. This eliminates options A and C.

Notice in option B, there is the formation of gaseous H_2O but in the equation, H_2O is formed as a liquid so we can eliminate option B.

Option D is the sum of the ΔH_f of the products with the correct stoichiometric coefficients. (D)

13 Nitrogen reacts with hydrogen to form ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia was allowed to reach equilibrium in a sealed vessel of volume 2 dm^3. When equilibrium was established. 2.32 mol of nitrogen were present in the equilibrium mixture.

Which expression will give the value of K_c?

A $\dfrac{(0.88)^2}{(1.16)(3.48)^3}$

B $\dfrac{(1.76)^2}{(2.32)(6.96)^3}$

C $\dfrac{(1.20)^2}{(1.16)(3.00)^3}$

D $\dfrac{(1.04)^2}{(1.16)(3.16)^3}$

By drawing an ICE table, we will be able to work out the amounts at equilibrium. We will also need to consider the volume of the container because K_c is calculated in terms of concentration.

	$N_2(g)$	$+3H_2(g)$	$\rightleftharpoons$	$2NH_3(g)$
Initial amt/ mol	2.00	6.00		2.40
Change/ mol	+0.32	+3(0.32)		-2(0.32)
Eqm amt/ mol	2.32	6.96		1.96
Eqm conc/ mol dm^{-3}	2.32/2 =1.16	6.96/2 = 3.48		1.96/2 = 0.88

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.88)^2}{(1.16)(3.48)^3}$$

(A)

14 In the reaction below, the concentrations of both **J** and **K** are reduced to half their original values whilst keeping the total volume of the solution constant.

$$\mathbf{J}(aq) + \mathbf{K}(aq) \rightarrow \mathbf{JK}(aq)$$

Simultaneously, the temperature was raised from 298 K to 348 K.

Which prediction is definitely true?

A A smaller proportion of collisions between particles of **J** and particles of **K** will be effective.

B The average kinetic energy of particles of **J** and particles of **K** will increase.

C The rate of the reaction will be unaffected.

D The frequency of collisions between particles **J** and particles of **K** will halve.

The concentration of both **J** and **K** are halved which means that number of particles of **J** and **K** in the system are both halved.

The temperature of the system was increased by 50 K.

When the temperature is increased, the average kinetic energy of particles **J** and **K** will increase.

Any collisions that take place will have a higher chance of being effective as the particles will now have $E \geq E_a$

While the number of particles of **J** and **K** in the system are both halved, the frequency of collisions will increase because of the increase in temperature. As such the rate of reaction will also be affected.

(B)

15 The rate equation for the reaction

$$S_2O_8^{2-}(aq) + 2I^- \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

is rate = $k[S_2O_8^{2-}][I^-]$, where k was found to be 0.2 mol^{-1} dm^3 s^{-1} at temperature T.

What is the half-life of the reaction when $S_2O_8^{2-}$ is present in a large excess at concentration of 0.4 mol dm^{-3} at the same temperature?

A 0.35 s

B 1.39 s

C 3.76 s

D 8.66 s

When $S_2O_8^{2-}$ is present in large excess, $[S_2O_8^{2-}]$ can be treated as a constant.
The rate equation can then be rewritten as rate = $k'[I^-]$ where $k' = k[S_2O_8^{2-}]$.
This creates a pseudo first order reaction and we can make use of the equation
$t_{½} = \ln 2/k'$ to work out the half-life.
$t_{½} = \ln 2/k' = \ln 2/(0.2 \times 0.4) = 8.66s$
(D)

16 The value of pK_w at 40 °C is 13.54.

What is the pH of an aqueous solution of 0.05 mol dm^{-3} $Ba(OH)_2$ at 40 °C?

A 12.23

B 12.54

C 12.70

D 13.00

$Ba(OH)_2$ is a strong base and dissociates completely.
$[OH^-] = 0.05 \times 2 = 0.10$ mol dm^{-3}
At 40 °C, $pK_w = 13.54$ ➔ $K_w = 10^{-13.54}$
Since $K_w = [H^+][OH^-]$
$[H^+] = 10^{-13.54} / 0.10 = 2.88 \times 10^{-13}$
$pH = -\lg(2.88 \times 10^{-13}) = 12.54$
(B)

17 The numerical values of the solubility products at 25 °C for AgBr and AgI are 7.7×10^{-13} and 8.0×10^{-17} respectively.

What is the value of the equilibrium constant for the reaction below?

$$AgBr(s) + I^-(aq) \rightleftharpoons AgI(s) + Br^-(aq)$$

A 6.2×10^{-29}

B 1.0×10^{-4}

C 9.8×10^{1}

D 9.6×10^{3}

K_{sp} expression for AgBr = $[Ag^+][Br^-]$

K_{sp} expression for AgI = $[Ag^+][I^-]$

K_c for the equilibrium given = $\frac{[Br^-]}{[I^-]}$

When the system is in equilibrium, $[Ag^+]$ will equilibrate to give the same value,

$K_c = \frac{[Ag^+]\,[Br^-]}{[Ag^+]\,[I^-]}$

$K_c = 7.7 \times 10^{-13}/8.0 \times 10^{-17} = 9465 = 9.6 \times 10^{3}$

(D)

18 The table gives the concentrations and pH values of the aqueous solutions of three compounds, **H**, **I** and **L** at 25 °C. Each compound could be an acid or a base.

	H	**I**	**L**
concentration /mol dm^{-3}	1.00	1.00	1.00×10^{-4}
pH	3	14	4

Which statements are correct?

1 **H** is a strong acid and **I** is a strong base.

2 The extent of dissociation of **H**(aq) is greater than **L**(aq).

3 When equal volumes of **H** and **I** are mixed, a solution of pH > 7 is obtained.

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 3 only

For **H**, $[H^+] = 1.0 \times 10^{-3}$

Since $[H^+] < [\mathbf{H}]$, **H** is a weak acid

For **I**, since pH = 14.0 ➔ $[OH^-] = 1.00 = [\mathbf{I}]$

I is a strong base.

Statement 1 is incorrect.

For **L**, $[H^+] = 1.0 \times 10^{-4} = [\mathbf{L}]$

L is a strong acid.

Since strong acids dissociate completely and weak acids dissociate partially, **L** will have a greater extent of dissocation that **H**.

Statement 2 is incorrect.

When equal volumes of weak acid **H** and strong base **I** are mixed and their concentrations are the same, there will be complete neutralisation and the salt obtained will be the conjugate base of the weak acid **H**. The salt undergoes hydrolysis and the pH of the resulting solution will be > 7.

Statement 3 is correct.

(D)

19 The formula $[CH_3]^x$ (where x can be 1–, 0 or 1+) can represent an anion, a cation or a free radical. Species with the formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons present on the central carbon atom.

How many outer shell electrons must be present for $[CH_3]^x$ to act in these different ways?

	$[CH_3]^x$ as an electrophile	$[CH_3]^x$ as a free radical	$[CH_3]^x$ as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

For CH_3 to act as an electrophile, it will be CH_3^+ so that it can accept a lone pair of electrons. This means there are a total of 6 outer shell electrons on C.

For CH_3 to act as a free radical, it will be $\bullet CH_3$ where the C has an unpaired electron. This means that there are a total of 7 outer shell electrons on C.

For CH_3 to act as an electrophile, it will be CH_3^- with a lone pair of electrons on C. This means there are a total of 8 outer shell electrons on C.

(A)

20 Ethene reacts with aqueous bromine to form a mixture of two products.

Which statements are correct?

1 Both products can be hydrolysed to form the same diol.
2 Both products can form hydrogen bonds with water.
3 Both products are obtained in this reaction by electrophilic substitution.
4 Both products are obtained in this reaction by nucleophilic addition.

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

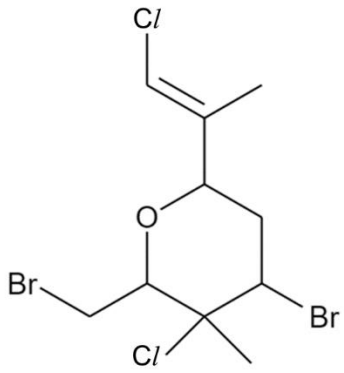
The reaction between C_2H_4 and $Br_2(aq)$ produces CH_2BrCH_2Br as well as $CH_2(OH)CH_2Br$ through electrophilic addition.
This means both statement 3 and 4 are incorrect.

Both can undergo hydrolysis to form $CH_2(OH)CH_2OH$ (diol) where the Br is substituted with OH group.
Statement 1 is correct.

Only $CH_2(OH)CH_2Br$ has the OH group that can form hydrogen bonds with H_2O.
Statement 2 is incorrect.

(C)

21 Red algae found in marine habitats have been found to be a source of natural products which show antibacterial bioactivity. One such compound is costatone C.



costatone C

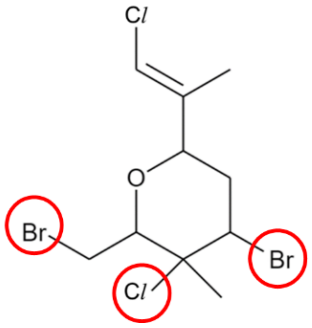
How many moles of halides (Cl^- and Br^-) can be obtained when one mole of costatone C is heated under reflux with an excess of NaOH(aq)?

A 1

B 2

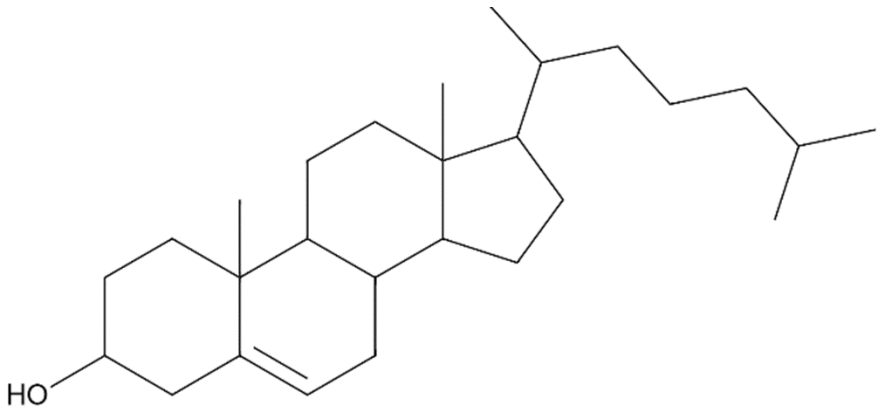
C 3

D 4



The three circled halides will undergo nucleophilic substitution. The C*l* directly bonded the alkene will not undergo nucleophilic substitution hence only 1 mole of Cl^- will be formed. (C)

22 Cholesterol is a natural occurring molecule that is essential for many metabolic processes in the human body.



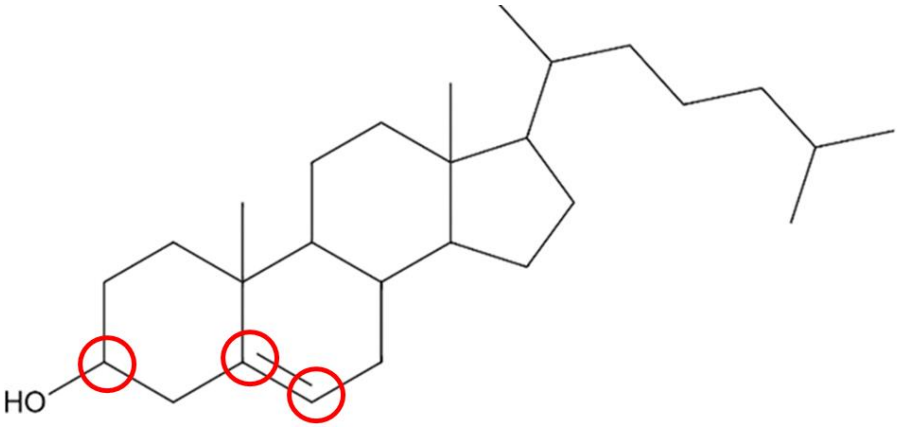
cholesterol

Cholesterol is separately treated with

- cold dilute, acidified $KMnO_4$,
- hot concentrated acidified $KMnO_4$.

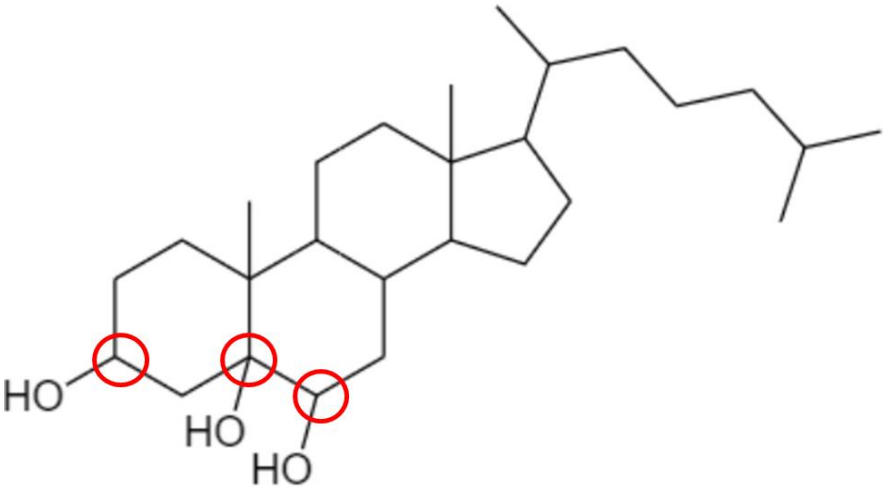
What is the change in the number of chiral carbon atoms in the molecule during each reaction?

	cold, dilute acidified $KMnO_4$	hot, concentrated acidified $KMnO_4$
A	+1	0
B	+1	–1
C	+2	0
D	+2	–1

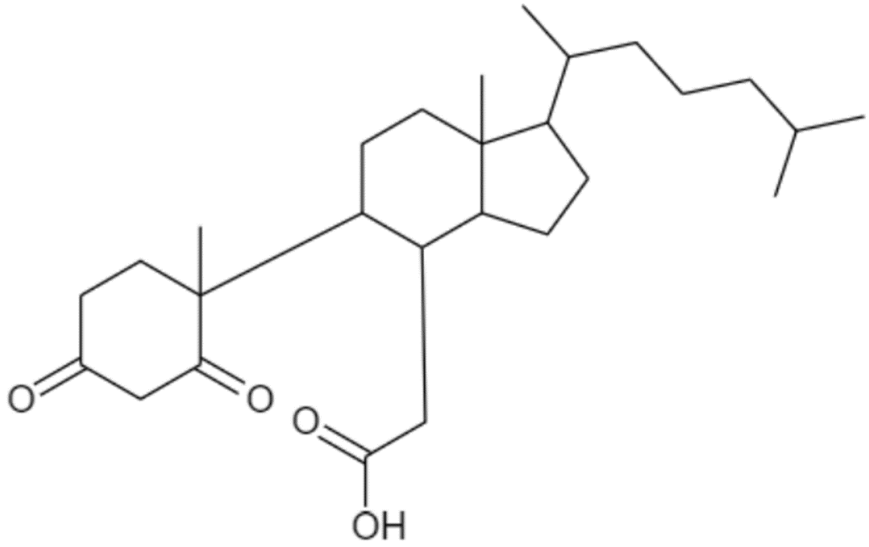


Reaction with $KMnO_4$ will affect these three carbons. The carbon with the alcohol is originally chiral.

On treatment with cold dilute $KMnO_4$, the alkene gets oxidised to form a diol while the alcohol group remains untouched. This causes an increase of 2 chiral carbons.



On treatment with hot concentrated $KMnO_4$, the alcohol gets oxidised to a ketone while the alkene undergoes strong oxidation. This causes a decrease of 1 chiral carbon.



(D)

23 Compound **N**, C_4H_8O, produces an orange precipitate when it is reacted with 2,4-dinitrophenylhydrazine. Compound **N** produces a carboxylic acid when heated under reflux with an acidified solution of potassium dichromate(VI).

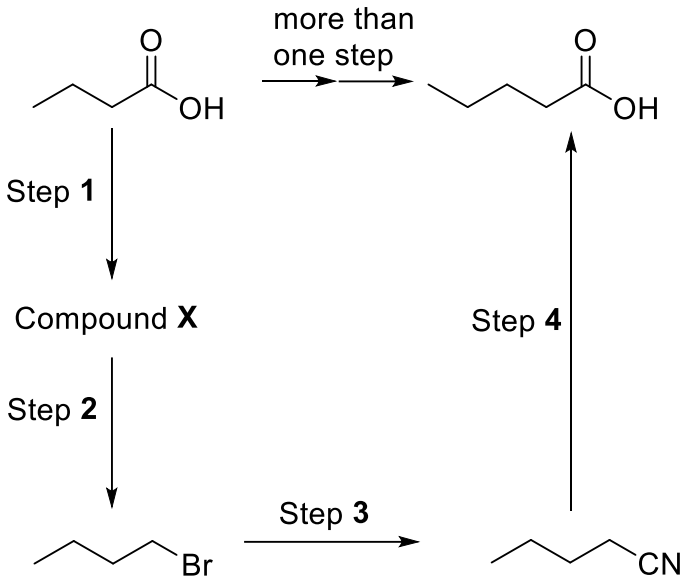
What could be the identity of compound **N**?

A butanal
B butanone
C 2-methylbutanal
D 4-hydroxybut-1-ene

Since **N** produces a orange ppt with 2,4-DNPH, it must be a carbonyl compound. We eliminate option D.
Since **N** can undergo oxidation by $K_2Cr_2O_7$ to form a carboxylic acid. It must be an aldehyde and hence we eliminate option B.

Notice that 2-methylbutanal has 5 carbons while **N** only has 4 carbons so it cannot be option C.
(A)

24 The following reaction scheme shows a suggested route for the conversion of butanoic acid to pentanoic acid.



Which of the following deductions about the reaction scheme are correct?

1 Step 1 can be achieved using ethanolic $NaBH_4$.

2 Step 2 is a nucleophilic substitution reaction.

3 Step 3 can be achieved by using cold HCN with trace amounts of NaCN.

A 1 only

B 2 only

C 2 and 3 only

D 1, 2 and 3

$NaBH_4$ is not strong enough to reduce carboxylic acids to alcohols. Deduction 1 is incorrect.

Step 2 involves the nucleophilic substitution reaction of the alcohol to form a bromoalkane. Deduction 2 is correct.

Step 3 is obtained by heating the bromoalkane with ethanolic NaCN. Deduction 3 is incorrect.

(B)

25 **Q** is a mixture of a Group 2 oxide and a Group 2 sulfate.

When **Q** is shaken with water and the resulting mixture is filtered, a solid residue and a colourless filtrate is obtained. There is no reaction when the solid residue is shaken with HC*l*(aq). Shaking the filtrate with H_2SO_4(aq) produced a white precipitate.

What could be the identity of **Q**?

A $BaO + BaSO_4$

B $BaO + MgSO_4$

C $MgO + BaSO_4$

D $MgO + MgSO_4$

For A: BaO will dissolve in water to form $Ba(OH)_2$ which is soluble in water and forms the filtrate. $BaSO_4$ is insoluble in water and forms the residue. $BaSO_4$ does not react with HC*l* so the white ppt remains. $Ba(OH)_2$ reacts with H_2SO_4 to form $BaSO_4$ which is a white ppt.

For B: Both BaO and $MgSO_4$ are soluble in water so no residue will be formed upon filtration hence it cannot be **Q**.

For C: MgO dissolves very slightly to form $Mg(OH)_2$ and $BaSO_4$ is insoluble in water so both MgO and $BaSO_4$ forms the residue while filtrate contains the small amount of $Mg(OH)_2$ formed. MgO dissolves when HC*l* is added but $BaSO_4$ does not react with HCl. The observation is that some of the residue dissolves. MgOH in the filtrate reacts with H_2SO_4 to form $MgSO_4$ which is soluble in water so no white ppt is formed. Hence it cannot be **Q**.

For D: MgO dissolves very slightly to form $Mg(OH)_2$ and $MgSO_4$ is soluble in water. The residue formed will be MgO while the filtrate will be $Mg(OH)_2$ and $MgSO_4$. MgO dissolves when HC*l* is added and no ppt is formed when H_2SO_4 is added to the filtrate containing $Mg(OH)_2$ and $MgSO_4$. Hence it cannot be **Q**.

(A)

26 **R** and **S** are in the third period of the Periodic Table.

The chloride of **R** gives an aqueous solution of pH = 7.

The oxide of **S** gives an aqueous solution which is weakly alkaline.

Which of the following statements is true?

A The atomic radius of **R** is smaller than **S**.

B The first ionisation energy of **R** is smaller than **S**.

C The electronegativity of **R** is greater than **S**.

D The atomic number of **R** is greater than **S**.

The only chloride that gives a neutral solution is NaCl. **R** is Na.

The only oxide that forms a weakly alkaline solution is MgO. **S** is Mg.

The atomic radius decreases across the period so atomic radius of Na > Mg.

Option A is incorrect.

First ionisation energy increases across the period so first IE of Na < Mg.

Option B is correct.

Electronegativity increases across the period so electronegativity of Mg > Na.

Option C is incorrect.

Atomic number increases from Na to Mg.

Option D is incorrect.

(B)

27 A student set up 4 standard half-cells each containing one of the metals, **T**, **U**, **V**, **W**, immersed in a solution of its metallic salts. These were then used to make different electrochemical cells.

The table below shows the standard electrode cell potential, $E^{\ominus}_{cell}$ and the positive terminal of each electrochemical cell.

Cell	Metals used	$E^{\ominus}_{cell}$ / V	Positive terminal
1	**T** and **U**	+1.10	**U**
2	**U** and **V**	+0.46	**V**
3	**U** and **W**	+0.47	**U**

Which of the following statements are true?

1 **T** can reduce all the cations of **U**, **V** and **W**.

2 **W** has a stronger reducing power than **V**.

3 **V** is produced in Cell 2.

A 1 only

B 2 and 3 only

C 1, 2 and 3

D 2 only

For electrochemical cells, electrons enter the positive terminal where reduction takes place. The positive terminal is the cathode.

E_{cell} = E (cathode) – E (anode)

For Cell 1:

When T and U are connected where U is the cathode ➔ E_{red} of U > E_{red} of T by 1.10 V

For Cell 2:

When U and V are connected where V is the cathode ➔ E_{red} of V > E_{red} of U by 0.46V

For Cell 3:

When U and W are connected where U is the cathode ➔ E_{red} of U > E_{red} of W by 0.47V

In order of decreasing oxidising power: V, U, W, T

T is the weakest oxidising agent which means it is the strongest reducing agent and able to reduce V, U and W.

Statement 1 is true

W is a weaker oxidising agent compared to V, which means it is a stronger reducing agent compared to V.

Statement 2 is true.

Since V is the cathode in cell 2, V will be produced in cell 2.

Statement 3 is true.

(C)

28 A student used an acidified solution of $Cr_2O_7^{2-}$ to electroplate a steel box with chromium metal. How long would it take for a current of 0.125 A to deposit 0.0312 g of chromium to plate the entire box?

A 463 s

B 1390 s

C 2780 s

D 5560 s

$Cr_2O_7^{2-} + 12e^- \rightarrow 2Cr$

amt of Cr required 0.0312/52 = 6.00×10^{-4} mol
amt of e^- required = $6.00 \times 10^{-4} \times 6 = 3.60 \times 10^{-3}$ mol
quantity of charge required = $3.60 \times 10^{-3} \times 96500 = 347.4$C
Q = It
t = 347.4 / 0.125 = 2780s
(C)

29 The unbalanced equation below involves manganese in different oxidation states.

$$MnO_4^{2-} \rightarrow Mn^{2+} + MnO_4^-$$

Which of the statements is **incorrect**?

A This is a disproportionation reaction.

B MnO_4^- solutions are purple due to d–d electronic transition.

C The amounts of Mn^{2+} and MnO_4^- formed are unequal.

D The 3d electrons in Mn^{2+} are all unpaired.

Balancing the equation

$5MnO_4^{2-} + 8H^+ \rightarrow Mn^{2+} + 4MnO_4^- + 4H_2O$

This is a disproportionation equation and the amounts of Mn^{2+} and MnO_4^- formed are unequal. Statements A and C are correct.

Mn in MnO_4^- has a +7 oxidation state which means it has no electrons in the 3d orbitals. Since there are no electrons in the 3d orbitals, the colour that is formed is not due to d-d electronic transition. Statement B is incorrect.

Mn^{2+} has 5 electrons in the 3d subshell, hence all of them are unpaired. Statement D is correct.

(B)

30 Rhodium and its compounds are often used as catalysts in many important reactions. Which of the following properties make rhodium a suitable heterogeneous catalyst?

A Rhodium has vacant d orbitals that are energetically accessible.

B Rhodium exhibits various oxidation states.

C Rhodium is able to form stable complexes.

D Rhodium is able to form coloured compounds.

For a heterogeneous catalyst, the reactants form weak bonds with the transition metal by using the vacant d orbitals that are energetically accessible.

(A)

END OF PAPER 1

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