Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

2823628517

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** 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.
Electronic calculators may be used.

This document consists of **14** printed pages and **2** blank pages.

CAMBRIDGE International Examinations

[Turn over

Section A

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

Use of the Data Booklet may be appropriate for some questions.

1 Why is the boiling point of ammonia, NH_3, higher than the boiling point of phosphine, PH_3?

A Ammonia molecules are polar; phosphine molecules are not.

B Ammonia molecules have significant hydrogen bonding; phosphine molecules do not. For hydrogen bonding we need N, F or O & a lone pair of electrons

C N–H covalent bonds are stronger than P–H covalent bonds.

D There is one lone pair in each ammonia molecule but no lone pair in each phosphine molecule.

2 Neutrons are passed through an electric field. The mass of one neutron relative to $\frac{1}{12}$ the mass of a ^{12}C atom and any deflection in the electric field is recorded.

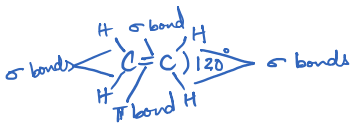
Which row is correct? Neutron carries 1 unit of mass & no charge

	mass of neutron	behaviour of beam of neutrons in an electric field
A	0	deflected
B	1	deflected
C	0	not deflected
D	1	not deflected

3 The table refers to the electron distribution in the second shell of an atom with eight protons. $2s^2 2p^4$

Which row is correct for this atom?

	orbital shape		orbital shape	
	orbital type	number of electrons	orbital type	number of electrons
A	p	2	s	4
B	p	4	s	2
C	s	2	p	4
D	s	4	p	2



3

4 Which statement describes the bond between carbon and hydrogen in an ethene molecule?

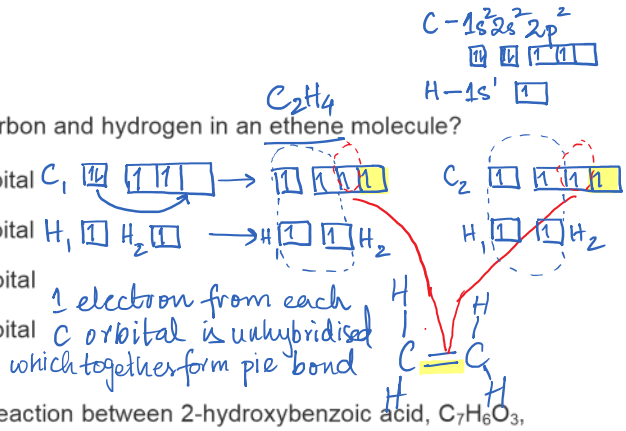
btw p orbital

A a π bond between an s orbital and an sp^2 orbital

B a π bond between an s orbital and an sp^3 orbital

C a σ bond between an s orbital and an sp^2 orbital

D a σ bond between an s orbital and an sp^3 orbital



5 Aspirin, $C_9H_8O_4$, M_r = 180.0, can be made by a reaction between 2-hydroxybenzoic acid, $C_7H_6O_3$, M_r = 138.0, and ethanoic anhydride, $C_4H_6O_3$, M_r = 102.0. The balanced equation for the reaction is shown.

$\frac{10}{138} = 0.0725$ $\frac{10}{102} = 0.09804$

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

limiting reagent: $0.0725 \rightarrow 0.0725$ = mass / 180 so it's 13.04g

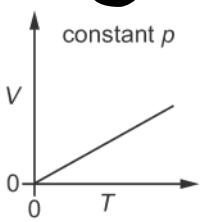
If a reaction mixture consists of 10.0 g of each of the two reactants, what is the maximum mass of aspirin that can be produced?

A 5.7 g B 10.0 g C 13.0 g D 17.6 g

6 Which diagram correctly describes the behaviour of a fixed mass of an ideal gas? (T is measured in K.)

$\frac{V}{T}$ = constant or $\frac{P}{T}$ = constant or PV = constant

A



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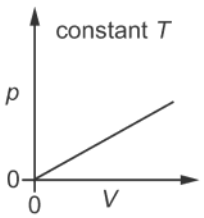

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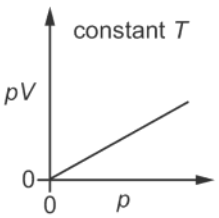
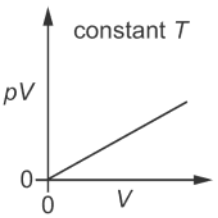


D



7 Anhydrous copper(II) chloride, $CuCl_2$, combines with water to form $CuCl_2.2H_2O$. The standard enthalpy changes of formation for this reaction are shown in the table.

	$\Delta H_f^\ominus$ / kJ mol^{-1}
H_2O	–286
$CuCl_2$	–206
$CuCl_2.2H_2O$	–808

$CuCl_2(s) + 2H_2O \xrightarrow{x} CuCl_2.2H_2O$

$-206 \quad 2(-286) \quad -808$

$Cu(s) + Cl_2(g) + 2H_2(g) + O_2(g)$

$-808 = -206 + 2(-286) + x$

$x = -301\,kJ/mol$

What is the standard enthalpy change of the reaction shown?

$$CuCl_2 + 2H_2O \rightarrow CuCl_2.2H_2O$$

A –1586 kJ mol^{-1}

B –316 kJ mol^{-1}

C –110 kJ mol^{-1}

(D) –30 kJ mol^{-1}

8 Xenon hexafluoride, XeF_6, reacts with water.

$$\overset{+6\ -1}{XeF_6} + 3\overset{+1\ -2}{H_2O} \rightarrow \overset{+6\ -2}{XeO_3} + 6\overset{+1\ -1}{HF}$$

Which statement is correct?

~~A~~ Hydrogen is reduced in this reaction. its oxidation state remains constant

~~B~~ Hydrogen is the only element oxidised in this reaction.

~~C~~ The only element oxidised in this reaction is xenon.

(D) This is not a redox reaction. Nothing is oxidised or reduced.

9 Hydrogen is produced industrially from methane as shown in the equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^\ominus = +205\,kJ\,mol^{-1}$$

Which conditions would most favour the formation of hydrogen?

	pressure	temperature
A	high	high
B	high	low
(C)	low	high
D	low	low

Since forward reaction is endothermic, high temp. would favour formation of $H_2(g)$. There are more moles on product side so lowering pressure would shift equilibrium towards the right.

10 The chemical equilibrium shown is formed when ammonia is produced in the Haber process.

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

The following concentrations are found to be present at equilibrium under certain conditions.

N_2	H_2	NH_3
0.200 mol dm^{-3}	0.300 mol dm^{-3}	0.600 mol dm^{-3}

$K_c = \dfrac{[NH_3]^2}{[H_2]^3[N_2]}$

$= \dfrac{(0.6)^2}{(0.3)^3(0.2)} = 66.7$

What is the numerical value of K_c under these conditions?

A 0.0150 **B** 6.0 **C** 10.0 **D** 66.7

11 The enzyme maltase (catalyst) speeds up the reaction between maltose and water.

$$\text{maltose + water} \xrightarrow{\text{maltase}} \text{glucose}$$

Maltase shows **specificity**.

Which statement describes the **specificity** of maltase?

A Maltase is a biological catalyst and it is a type of protein.

B Maltase is most effective between pH 6.1 and pH 6.8.

C Maltase lowers the activation energies of the reactions it catalyses.

D Maltase only speeds up a small number of chemical reactions.

12 Which description of the bonding and acid / base nature of aluminium oxide (Al_2O_3) is correct?

	bonding	acid / base nature
A	simple covalent ✗	amphoteric ✓
B	giant covalent ✗	basic only ✗
C	ionic ✓	amphoteric ✓
D	ionic ✓	basic only ✗

13 X and Y are elements of the third period.

($NaCl$, $MgCl_2$, $AlCl_3$, $SiCl_4$, PCl_5)

X and Y are individually heated in excess chlorine. Each product is purified and then separately added to water, producing two solutions. Both solutions have a pH of less than 5.

($AlCl_3$, $SiCl_4$ or PCl_5 bcz NaCl & $MgCl_2$ dissolve in water)

What could be X and Y?

A Na and P **B** Mg and Al **C** Mg and Si **D** Si and P

14 An ore contains magnesium carbonate ($MgCO_3$) and barium carbonate ($BaCO_3$). A sample of the ore is dissolved in nitric acid.

$MgCO_3 + BaCO_3 + HNO_3 \longrightarrow MgNO_3 + BaNO_3 + CO_2 + H_2O$

How could this solution be processed into a magnesium compound and a separate barium compound?

A Add HCl(aq), filter off the solid barium chloride. both are soluble so cant filter

B Add HCl(aq), filter off the solid magnesium chloride.

C Add H_2SO_4(aq), filter off the solid barium sulfate. insoluble so can be separated

D Add H_2SO_4(aq), filter off the solid magnesium sulfate. soluble in water

15 When calcium and calcium hydride, CaH_2, react separately with water, they each produce a white solid and a colourless gas. The white solid is the same compound in each reaction.

Which statement is correct?

$Ca + H_2O \longrightarrow Ca(OH)_2 + H_2$

$CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2$

A Both Ca and CaH_2 produce H_2.

B Both Ca and CaH_2 produce O_2.

C Ca produces H_2 and CaH_2 produces O_2.

D Ca produces O_2 and CaH_2 produces H_2.

$H_2SO_4 + NaCl \longrightarrow HCl + Na_2SO_4$ (only)

16 When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but not Cl_2.

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

$H_2SO_4 + NaI \longrightarrow Na_2SO_4 + HI$ &

$HI + H_2SO_4 \longrightarrow I_2 + \ldots$

A Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised. contradicts fact

B Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised bcz I^- is a better reducing agent & gets oxidised while Cl^- is a better oxidising agent

C Sulfuric acid is a reducing agent and chloride ions are more easily reduced.

D Sulfuric acid is a reducing agent and iodide ions are more easily reduced.

17 Silver chloride and silver iodide form equilibria when added to water.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \qquad K_c = K_1 \quad K_1 = [Ag^+][Cl^-]$$

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq) \qquad K_c = K_2 \quad K_2 = [Ag^+][I^-]$$

Each equilibrium position lies well to the **left**. meaning K_1 & K_2 are very low

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad K_c = K_3$$ meaning K_3 is high

The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

~~A~~ $K_1 > K_2 > K_3$

~~B~~ $K_2 > K_1 > K_3$

C $K_3 > K_1 > K_2$

D $K_3 > K_2 > K_1$

More soluble then more ions in solution & K_c gets a larger value. Thus $K_2 < K_1$

18 Elements and their compounds are important as catalysts.

In which process is a compound used, rather than an element?

~~A~~ catalytic converters Platinum

B Contact process Vanadium(V) oxide

~~C~~ Haber process Iron

~~D~~ hydrogenation of alkenes Nickel

19 The gaseous products of heating a mixture of $Ca(OH)_2$ and NH_4Cl are passed through solid CaO. This absorbs water vapour and a gas, **W**, is collected. NH_3

A sample of **W** is oxidised by $Cl_2(g)$ to produce two gases, **X** and **Y**.

N_2 **X** is an element. HCl **Y** is acidic.

NH_4Cl **Y** reacts with **W** to produce **Z**.

$$Ca(OH)_2 + NH_4Cl \longrightarrow CaCl_2 + NH_3 + H_2O$$

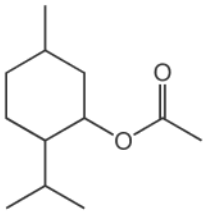
$$NH_3 + Cl_2 \longrightarrow N_2 + HCl \quad (g)$$

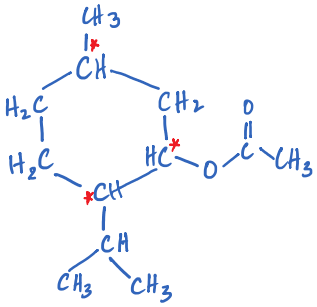
$$HCl + NH_3 \longrightarrow NH_4Cl$$

What are **X** and **Z**?

	X	Z
A	N_2	$CaCl_2$ ✗
B	N_2	NH_4Cl ✓
C	O_2	$CaCl_2$ ✗
D	O_2 ✗	NH_4Cl ✓

20 Molecule G is shown.





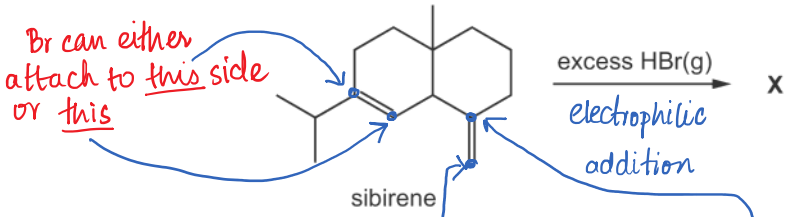
G

How many chiral centres are present in each molecule of G?

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

tertiary NOT secondary

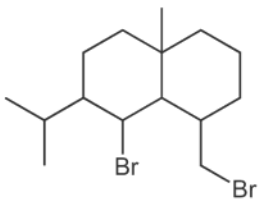
21 Sibirene, $C_{15}H_{24}$, is reacted with an excess of HBr(g). The major product is **X**.



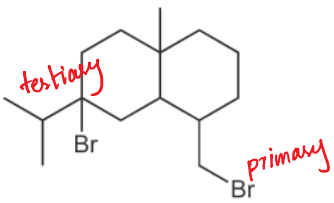
What is the skeletal formula of **X**?

Br can either attach to this side or this

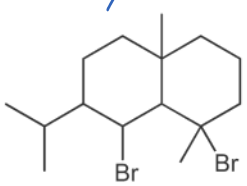
A



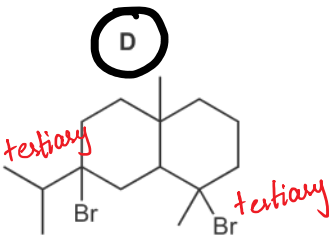
B



C



D

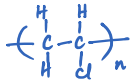


22 Which statement is **not** correct?

A Combustion of PVC produces a highly acidic gas. ✓

B PVC molecules are saturated. ✓ bc2 single bonds

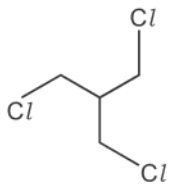
C The empirical formula of PVC is the same as the empirical formula of its monomer. ✓ $C_2H_4 \rightarrow (C_2H_4)_n$

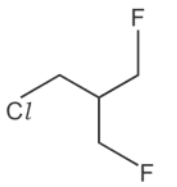
D The repeat unit of PVC is ~~–(CHClCHCl)–~~. 

23 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate. $AgNO_3$

$Cl^- \rightarrow$ white ppt
$Br^- \rightarrow$ cream ppt
$I^- \rightarrow$ yellow ppt.

Which compound would be the quickest to produce a precipitate? Cl weakest among others

A


B


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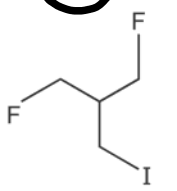

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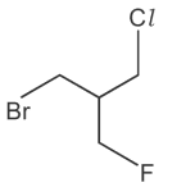


24 Halogenoalkanes react with NaOH(aq) either by an S_N1 mechanism or by an S_N2 mechanism. The mechanism followed by the reaction depends on the structure of the halogenoalkane.

alcohol produced — tertiary halogenoalkane — primary/secondary

This question is about the reaction of 3-bromo-3-ethylpentane, $(C_2H_5)_3CBr$.

Which statement is correct?

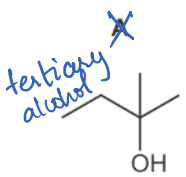
A The mechanism is S_N1, due to the stabilisation of an intermediate anion by three alkyl groups.

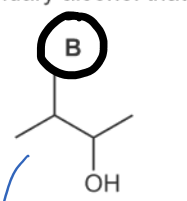
B The mechanism is S_N1, due to the stabilisation of an intermediate cation by three alkyl groups.

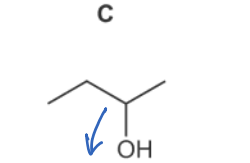
C The mechanism is S_N2, due to the stabilisation of an intermediate anion by three alkyl groups.

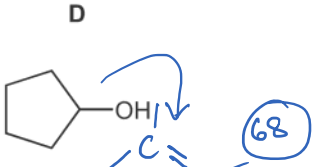
D The mechanism is S_N2, due to the stabilisation of an intermediate cation by three alkyl groups.

25 Which compound is a secondary alcohol that can be dehydrated to form an alkene with $M_r = 70$?

A

tertiary alcohol

B

70

C

56

D

68

26 When 0.0075 mol of alcohol X are completely burnt in excess oxygen and the gases produced are passed through an excess of limewater (calcium hydroxide solution), 3.0 g of calcium carbonate are produced.

When X is warmed with acidified potassium dichromate(VI) there is a colour change from orange to green.

What could be the identity of X?

A $CH_3CH(OH)CH_2CH_3$

B $(CH_3)_3COH$

C $CH_3CH_2CH_2OH$

D $CH_3CH(OH)CH_3$

primary or alcohol

$C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

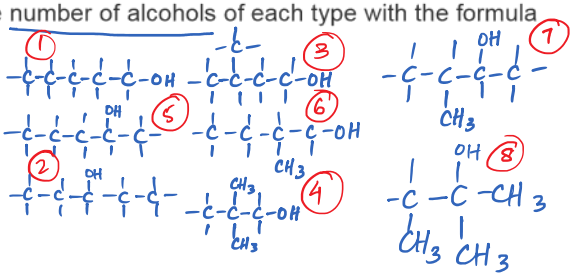
$0.0075\,mol \rightarrow 0.03\,mol \times 24 = 0.72\,dm^3$ of $CO_2(g)$

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

$0.03\,mol \rightarrow 0.03 \times 100.1 = 3\,g$ of $CaCO_3$

27 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3 ✗	3	2
B	4 ✓	2	2
C	4 ✓	3 ✓	1
D	5 ✗	2	1



28 A student carried out a **two-stage** synthesis in which $CH_3CH_2CH_2Br$ was converted into $CH_3CH_2CH_2CO_2H$.

3C atoms

4C atoms

halogenoalkane → nitrile → acid

Which compound could have been formed by the first stage of this synthesis?

A $CH_3CH_2CH_2OH$

B $CH_3CH_2CH_2CHO$

C CH_3CH_2CN

D $CH_3CH_2CH_2CN$

$CH_3CH_2CH_2Br \xrightarrow[\text{ethanolic}]{KCN} CH_3CH_2CH_2CN \xrightarrow[(aq)]{HCl} CH_3CH_2CH_2COOH$

29 An ester X has the structural formula $CH_3CO_2CH(CH_3)CH_2CH_3$. X can be prepared by heating an alcohol **Y**, under reflux, with ethanoic acid and an acid catalyst.

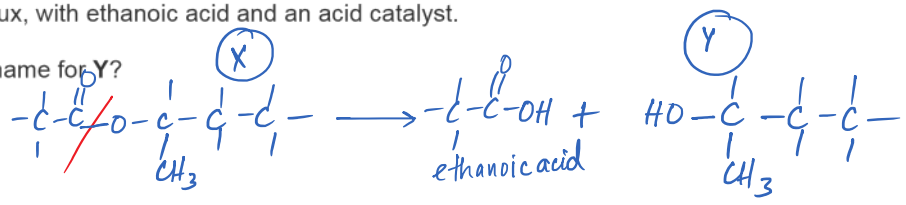
What is the correct name for **Y**?

A butan-1-ol

B butan-2-ol

C butan-3-ol

D methylpropan-2-ol

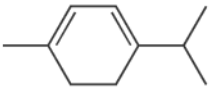
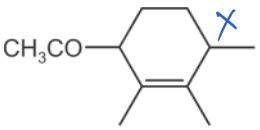
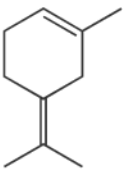


30 Compound **S** can be extracted from natural compounds. Reacting **S** with hot, concentrated $KMnO_4$ produces the organic product, **T**. Some of the absorptions found in the infra-red spectra of **S** and **T** are described.

S has no strong absorption between 1670 and 1740 cm^{-1}. not ketone or aldehyde C=O

T has a strong absorption at 1720 cm^{-1} but has **no** strong, broad absorption between 2500 and 3000 cm^{-1}. NOT R-CO_2H

From this information, what could be the formulae of **S** and **T**?

	S	T
A	$CH_3(CH_2)_5CH{=}CH_2$	$CH_3(CH_2)_5CO_2H$ X
B		$CH_3COCH_2CH_2COCH(CH_3)_2$
C	 X	$CH_3COCH(COCH_3)CH_2CH_2CH(COCH_3)CH_3$
D		$HO_2CCH_2CH_2COCH_2COCH_3$ X

Section B

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

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

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

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

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

Use of the Data Booklet may be appropriate for some questions.

31 Complete combustion of a sample of a hydrocarbon gave 0.132 g of carbon dioxide and 0.054 g of water.

Which formulae could correctly represent this hydrocarbon? **A**

✓ **1** $CH_2=CH_2$ $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ (88 g, 86 g)

✓ **2** $CH_3CH=CH_2$ $C_3H_6 + \frac{9}{2}O_2 \rightarrow 3CO_2 + 3H_2O$ (132 g, 54 g)

✓ **3** $CH_3CH=CHCH_3$ $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ (176 g, 72 g)

32 Which statements are correct? **A**

✓ **1** Magnesium carbonate decomposes at a lower temperature than calcium carbonate. Thermal stability ↑ down the group

✓ **2** Calcium hydroxide is more soluble in water than magnesium hydroxide. Solubility of hydroxides ↑ down the group

✓ **3** Calcium is a stronger reducing agent than magnesium. Reactivity of metals increases down the group

33 Ammonia and chlorine react as shown.

$$\overset{-3\,+1}{8NH_3} + \overset{0}{3Cl_2} \rightarrow \overset{0}{N_2} + \overset{-3\,+1}{6NH_4Cl}\ (-1)$$

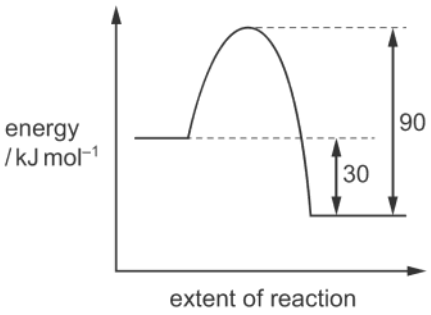
Which statements are correct? **C**

✗ **1** Each nitrogen atom is oxidised.

✓ **2** Each chlorine atom is reduced.

✓ **3** Ammonia behaves as a base.

34 The diagram shows the reaction pathway for a reversible reaction.



$\Delta H = -30$ kJ/mol
$E_a = 90$ kJ/mol

Which statements are correct? **B**

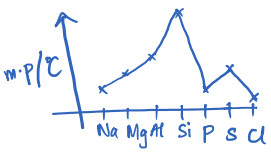
1 ✓ The forward reaction is exothermic.

2 ✓ The enthalpy change for the forward reaction is –30 kJ mol^{-1}.

3 ✗ The enthalpy change for the backward reaction is +90 kJ mol^{-1} +30 kJ/mol

35 The structure of metals is considered to be positive ions surrounded by delocalised electrons.

The melting points of the metals in Period 3 increase with increasing atomic number.



Which statements help to explain this trend from sodium to aluminium? **A**

1 ✓ The charge on the metal ion increases. $Na^+ \rightarrow Mg^{2+} \rightarrow Al^{3+}$

2 ✓ There are more delocalised electrons per metal ion. proton no. ↑

3 ✓ The radius of the metal ion decreases. More electrons, in the same shell, are added.

36 Under room conditions, 600 cm^3 of a gas, X, has a mass of 0.700 g.

101·3 kPa, 293K 6×10^{-4} m^3

What could X be? **A**

$101{\cdot}3\times10^{3} \times 6\times10^{-4} = \frac{0{\cdot}7}{Mr} \times 8{\cdot}314 \times 293$

$Mr = 28{\cdot}0553$

1 ✗ carbon monoxide 28

2 ✓ ethene 28

3 ✗ nitrogen 28

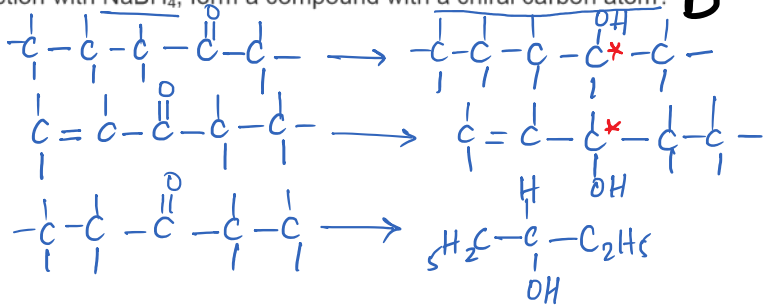
37 Which compounds, on reaction with $NaBH_4$, form a compound with a chiral carbon atom? **B**

reduces ketone NOT acids

1 ✓ $CH_3CH_2CH_2COCH_3$

2 ✓ $CH_2CHCOCH_2CH_3$

3 ✗ $CH_3CH_2COCH_2CH_3$



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

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

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

38 Compound Y is a straight chain molecule with formula $C_nH_{2n+1}X$. X is a halogen. The M_r of Y is 137. The halogen atom is on the second carbon atom in the chain.

secondary halogenoalkane

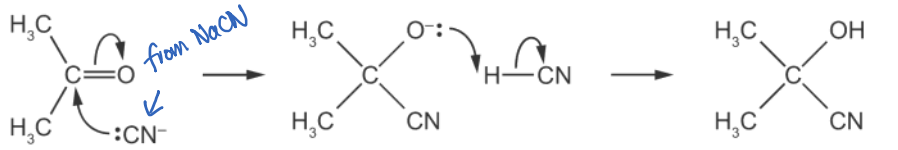
Which statements are correct? **A**

1 Y contains a chiral centre.

2 Y can eliminate HX to form two structurally isomeric alkenes.

3 Y can eliminate HX to form two geometrically isomeric alkenes.

39 Propanone and hydrogen cyanide react together by the mechanism shown.



goes to Na+ to form back NaCN which is a catalyst

Which statements about this mechanism are correct? **C**

1 CN^- is an electrophile. a nucleophile

2 It is an addition reaction. nucleophilic addition

3 Heterolytic bond breaking is involved. H—CN breaks heterolytically

40 Acrolein is an organic compound with the molecular formula C_3H_4O. It is used in water treatment and as a herbicide. When acrolein reacts with 2,4-dinitrophenylhydrazine an orange precipitate is obtained. Reaction of acrolein with Tollens' reagent produces a silver mirror.

NOT ethanal

only CHO is present

CHO or CO is present

Which statements are correct? **C**

1 Acrolein reacts with alkaline aqueous iodine to produce a yellow precipitate. only aldehyde that reacts is ethanal

2 Acrolein can be reduced to a primary alcohol.

3 Acrolein decolourises bromine water.

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