

11 Two chemicals, X and Y, react together in solution to give product Z.

The rate of formation of product Z at the start of the reaction was measured in five experiments, 1–5, using various concentrations of X and Y. The results are shown.

experiment number	starting concentration of X / mol dm ⁻³	starting concentration of Y / mol dm ⁻³	rate of formation of Z at the start / mol dm ⁻³ s ⁻¹
1	0.10	0.10	0.0001
2	0.10	0.20	0.0004
3	0.10	0.40	0.0016
4	0.20	0.10	0.0001
5	0.40	0.10	0.0001

Which statement is correct?

- A The rate of the reaction is directly proportional to the concentration of reagent X.
- B The rate of the reaction is directly proportional to the concentration of reagent Y.
- C The rate of the reaction is **not** affected by the concentration of reagent X.
- D The rate of the reaction is **not** affected by the concentration of reagent Y.

23 Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

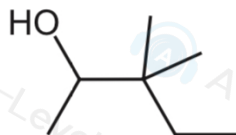
P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

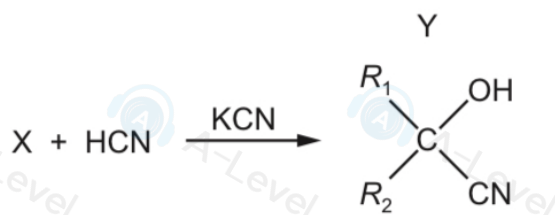
- A Br and H B Br and CH₃ C Br and C₂H₆ D CH₃ and CH₃Br

21 What is the correct name for the compound shown?



- A 1,2,2-trimethylbutan-3-ol
- B 2-ethyl-2-methylbutan-2-ol
- C 3,3-dimethylpentan-2-ol
- D 4-hydroxy-3,3-dimethylpentane

- 26 The diagram shows the formation of compound Y from compound X in a chemical reaction. R_1 and R_2 are alkyl groups.



Which row about this reaction is correct?

	mechanism	compound X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	ketone
D	nucleophilic addition	aldehyde

- 29 The free-radical substitution reaction between methane and chlorine involves initiation, propagation and termination stages.

Which row is correct?

	involved in initiation stage	radical produced in a propagation stage
A	homolytic fission	$\text{H}\cdot$
B	homolytic fission	$\text{CH}_3\cdot$
C	heterolytic fission	$\text{H}\cdot$
D	heterolytic fission	$\text{CH}_3\cdot$

- 6 Which statement about the Cl-N=O molecule is correct?

- A Each molecule contains one σ and two π bonds.
- B It is a non-polar molecule.
- C It is a linear molecule.
- D The nitrogen atom is sp^2 hybridised .

39 The formula shows the repeat unit of an addition polymer.



What is the correct name of the monomer from which this polymer is made?

- A 1-methyl-2-ethylethene
- B 1-ethylprop-1-ene
- C pent-2-ene
- D pent-1-ene

28 Ethene reacts with aqueous bromine to give two products, $\text{CH}_2\text{BrCH}_2\text{Br}$ and $\text{CH}_2\text{BrCH}_2\text{OH}$.

Which statement about these products is correct?

- A Both products are obtained in this reaction by nucleophilic substitution.
- B Both products are obtained in this reaction by nucleophilic addition.
- C Both products can be hydrolysed to form the same organic compound.
- D Both products can form hydrogen bonds with water.

39 Two carbonyl compounds have the molecular formula $\text{C}_3\text{H}_6\text{O}$.

Which reagents give **different** observations with these two compounds?

- 1 acidified aqueous potassium manganate(VII)
- 2 Fehling's reagent
- 3 alkaline aqueous iodine

3 Zinc reacts with concentrated nitric acid giving three products only: zinc nitrate, an oxide of nitrogen and water.

3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.

What could be the formula of the oxide of nitrogen?

- A N_2O
- B NO
- C N_2O_3
- D NO_2

7 A weather balloon is filled with 12.0 kg helium. The weather balloon reaches a height of 20 km, the pressure inside the balloon is 6000 Pa and the temperature is 216 K.

What is the volume of the weather balloon at this height, correct to three significant figures?

- A 897 dm^3
- B 1790 dm^3
- C $897\,000 \text{ dm}^3$
- D $1\,790\,000 \text{ dm}^3$

12 A mixture of two Period 3 oxides are added to water. A solution forms with a pH of just below 7.

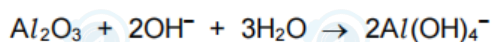
What could be the constituents of the mixture?

- 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}

5 A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

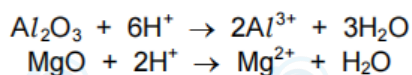
100 cm^3 of 2 mol dm^{-3} NaOH(aq) is just enough to dissolve the aluminium oxide in x grams of the mixture.

The reaction is shown.



800 cm^3 of 2 mol dm^{-3} HCl(aq) is just enough to dissolve **all** of the oxide in x grams of the mixture.

The reactions are shown.



How many moles of each oxide are present in x grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

22 X, Y and Z are three elements in Group 17.

X_2 has weaker covalent bonds than Y_2 .

X_2 has stronger instantaneous dipole-induced dipole forces between its molecules than Z_2 .

Y_2 is a stronger oxidising agent than Z_2 .

What could be X, Y and Z?

	X	Y	Z
A	Br	Cl	I
B	Cl	Br	I
C	I	Br	Cl
D	I	Cl	Br

25 A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

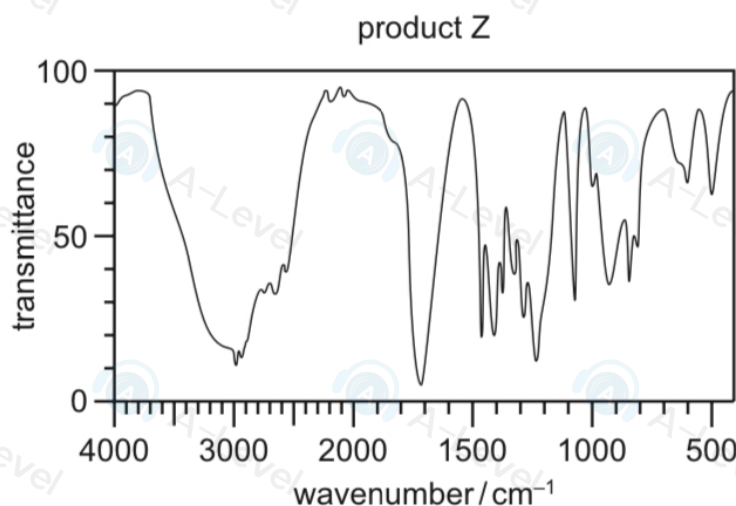
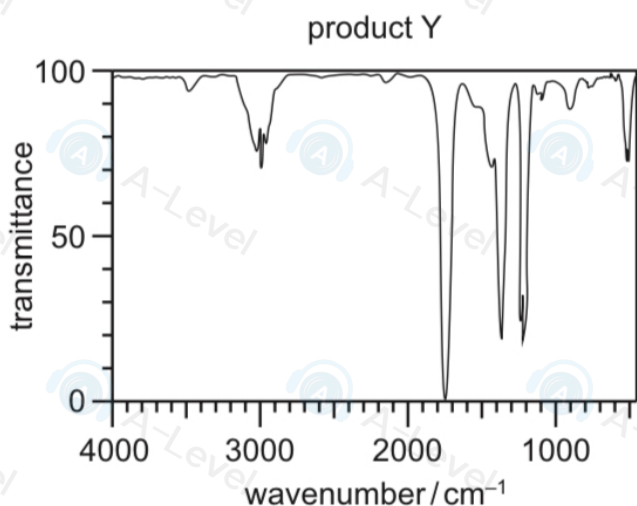
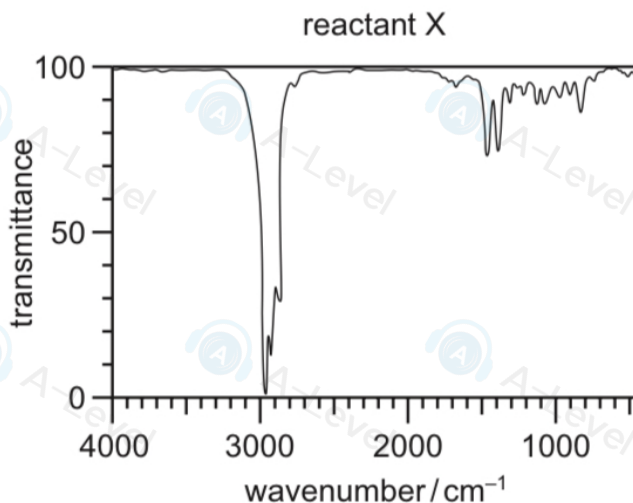
What could be the halogenoalkane?

- A 1-bromo-2-methylbutane
- B 2-bromo-2-methylbutane
- C 3-bromopentane
- D 1-bromo-2,2-dimethylpropane

37 Which reaction is a redox reaction?

- A ethanenitrile heated under reflux with dilute hydrochloric acid
- B ethanoic acid reacted with aqueous sodium hydroxide
- C ethanoic acid reacted with sodium
- D ethyl ethanoate heated under reflux with dilute hydrochloric acid

- 30 When reactant X is treated with a suitable reagent, products Y and Z are formed. Infrared spectra of X, Y and Z are shown.



Which row could be correct?

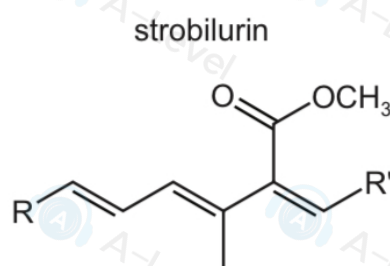
	X	Y	Z
A	2,3-dimethylpent-2-ene	propanone	butanone
B	2-methylpent-2-ene	propanone	propanoic acid
C	pent-2-ene	ethanoic acid	propanoic acid
D	propyl propanoate	propan-1-ol	propanoic acid

- 27 The molecular formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons on the central carbon atom must be present for CH_3 to act in these different ways?

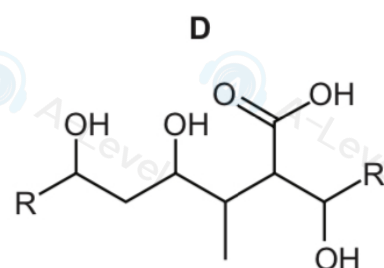
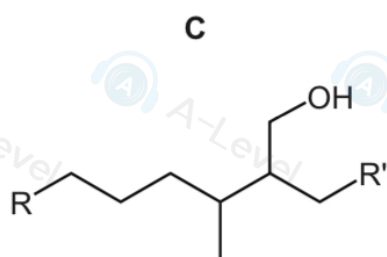
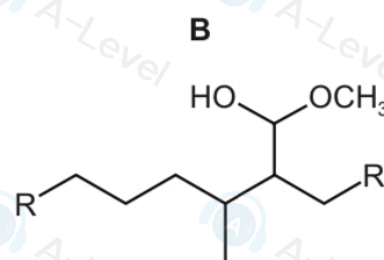
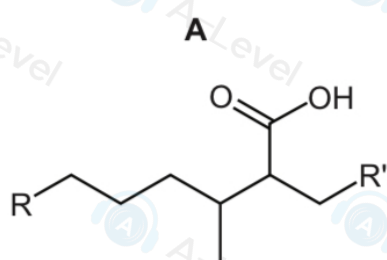
	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

- 23 Part of the structure of strobilurin is shown. R and R' are inert groups.



Strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

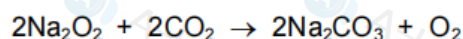
What could be the structure of compound Y?



20 Which pair of compounds are functional group isomers of each other?

- A butan-1-ol and butanal
- B ethylpropanoate and pentanoic acid
- C hex-1-ene and hex-2-ene
- D propylamine and propanenitrile

2 Sodium peroxide, Na_2O_2 , is used to absorb carbon dioxide from the atmosphere and release oxygen in closed environments such as space capsules and submarines.



Which mass of sodium peroxide would be required to remove 2.4 dm^3 of carbon dioxide from the atmosphere at room temperature and pressure?

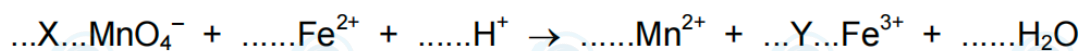
- A 2.4g B 3.9g C 7.8g D 15.6g

3 A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas. This is the only carbon-containing product formed in the reaction. This methane gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 produced at room temperature and pressure is 108 cm^3 .

What is the formula of aluminium carbide?

- A Al_2C_3 B Al_3C_2 C Al_3C_4 D Al_4C_3

12 KMnO_4 is an oxidising agent. Its reaction with Fe^{2+} is shown in the following ionic equation.



What are X and Y when the equation is balanced?

	X	Y
A	1	1
B	1	3
C	1	5
D	5	1

22 J dissolves in water to give an aqueous solution K.

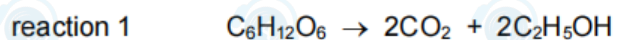
K gives a dense white precipitate when aqueous silver nitrate is added.

When heated with aqueous potassium hydroxide, K gives off a gas that turns moist universal indicator paper blue.

What is J?

- A ammonium chloride
- B ammonium sulfate
- C sodium chloride
- D sodium hydroxide

8 The equation for reaction 1 is shown.

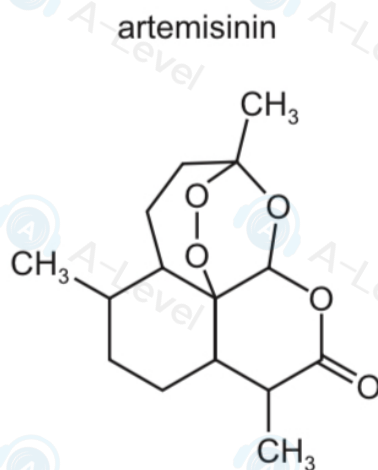


	$\Delta H_c^\ominus / \text{kJ mol}^{-1}$
$\text{C}_6\text{H}_{12}\text{O}_6$	a
$\text{C}_2\text{H}_5\text{OH}$	b

What is the correct expression for the enthalpy change of reaction 1?

- A $a + b$ B $a - b$ C $a + 2b$ D $a - 2b$

27 Artemisinin is a powerful anti-malarial drug.

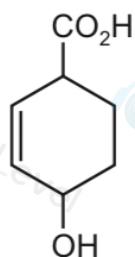


How many chiral centres are there in each molecule of artemisinin?

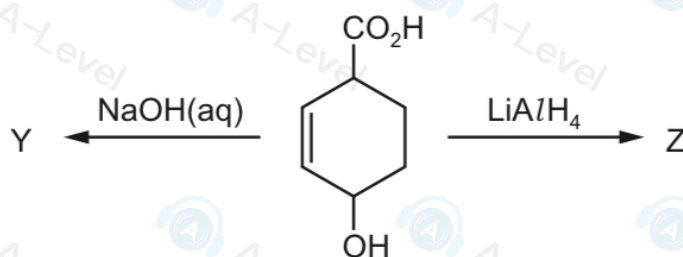
- A 4 B 6 C 7 D 8

20 Compound X is shown.

compound X



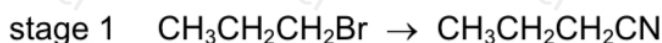
X is treated separately with NaOH(aq) and LiAlH₄ to give Y and Z.



What are Y and Z?

	Y	Z
A		
B		
C		
D		

24 Butanoic acid can be made from 1-bromopropane in two stages.

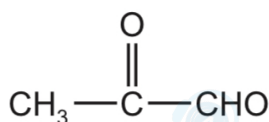


Which types of reaction are stage 1 and stage 2?

	stage 1	stage 2
A	electrophilic addition	hydrolysis
B	electrophilic addition	oxidation
C	nucleophilic substitution	hydrolysis
D	nucleophilic substitution	oxidation

23 Compound X contains two functional groups.

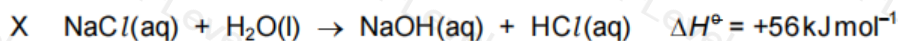
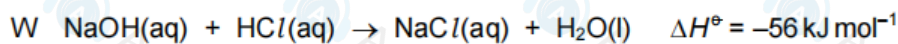
compound X



Which reagent will react with **only one** of the functional groups?

- A acidified potassium dichromate(VI)
- B 2,4-DNPH reagent
- C hydrogen cyanide
- D NaBH_4

10 The enthalpy changes for the possible reactions W, X, Y and Z are given.



Which statement about the activation energies of these reactions is correct?

- A X is greater than W; Z is greater than Y.
- B X is greater than W; Y is greater than Z.
- C W is greater than X; Z is greater than Y.
- D W is greater than X; Y is greater than Z.

19 Magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride.

Which statement explains this observation?

- A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+ .
- B NH_4Cl dissociates less fully than NaCl .
- C The Na^+ and Mg^{2+} ions have the same number of electrons.
- D The NH_4^+ ion can donate a proton.

27 Compound X, $\text{C}_5\text{H}_{10}\text{O}_3$, has one chiral carbon atom per molecule. Compound X produces bubbles with Na but **not** with Na_2CO_3 .

Which formula could represent compound X?

- A $(\text{CH}_3)_2\text{C}(\text{OH})\text{CO}_2\text{CH}_3$
- B $\text{HOCH}_2\text{CH}(\text{CH}_3)\text{CO}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)(\text{OH})\text{CO}_2\text{H}$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CH}_3)\text{CO}_2\text{H}$

29 Cyclohexene, C_6H_{10} , is a hydrocarbon with a six-membered ring of carbon atoms.

It has several structural isomers that are straight-chain alkenes. The number of double bonds in each of these molecules is P.

What is the shape of the cyclohexene molecule and what is the value of P?

	shape	P
A	planar	1
B	planar	2
C	non-planar	1
D	non-planar	2

36 The bondP..... of the HBr molecule isQ..... than that of the HI molecule.

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

35 Compound X contains a single ester group.

X contains 27.6% by mass of oxygen.

Which pair of products could be produced by the hydrolysis of X?

- A butan-1-ol and ethanoic acid
- B ethanol and propanoic acid
- C methanol and methanoic acid
- D propan-2-ol and butanoic acid

35 1-bromopropane reacts with hot ethanolic NaOH.

What is the molecular formula of the product in this reaction?

- A C_3H_6 B C_3H_8 C C_3H_7O D C_3H_8O

29 When bromoethane reacts with hot ethanolic sodium hydroxide a colourless gas is formed. This gas decolourises aqueous bromine.

What is the colourless gas?

- A 1,2-dibromoethane
- B ethanol
- C ethene
- D hydrogen bromide

22 The colours of the silver halides $AgCl$, $AgBr$ and AgI differ.

The solubilities of these halides in aqueous ammonia also differ.

Which row is correct?

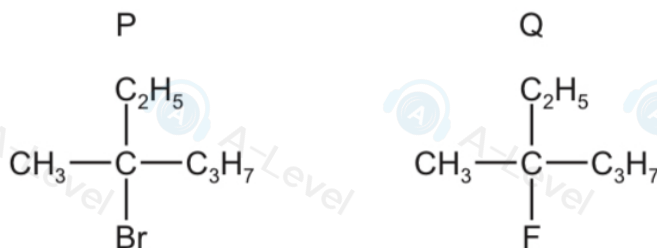
	colour of $AgBr$	silver halide that is most soluble in $NH_3(aq)$
A	cream	$AgCl$
B	cream	AgI
C	yellow	$AgCl$
D	yellow	AgI

31 A sample of 2.30 g of ethanol is mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture is boiled under reflux for one hour. The required organic product is then collected by distillation. The yield of product is 60.0%.

Which mass of product is collected?

- A 1.32g B 1.38g C 1.80g D 3.00g

31 The diagram shows the structures of two halogenoalkanes, P and Q.

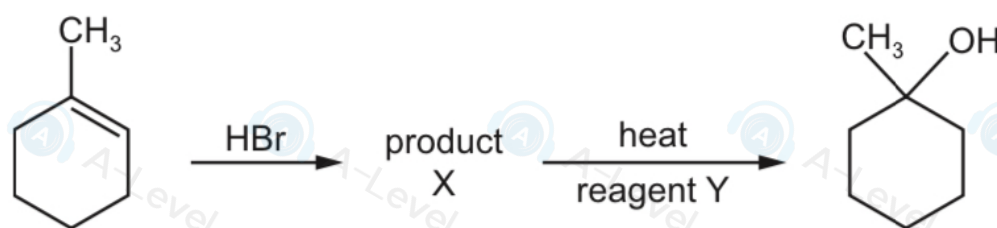


Both compounds can be hydrolysed.

Which row is correct?

	compound more readily hydrolysed	reaction mechanism
A	P	$\text{S}_{\text{N}}1$
B	P	$\text{S}_{\text{N}}2$
C	Q	$\text{S}_{\text{N}}1$
D	Q	$\text{S}_{\text{N}}2$

29 The diagram shows a synthetic route to produce 1-methylcyclohexanol.



What is reagent Y?

- A aqueous NaOH
 B cold dilute KMnO_4
 C ethanolic NaOH
 D hot concentrated KMnO_4

5 Ethane and ethene are both hydrocarbon molecules.

What is a feature of **both** molecules?

- A a planar structure
- B bond angles of 109°
- C σ covalent bonds
- D π covalent bonds

36 Structural isomerism only should be considered when answering this question.

How many compounds with molecular formula $C_5H_{11}Br$ are **primary** halogenoalkanes?

- A 4 B 5 C 7 D 8

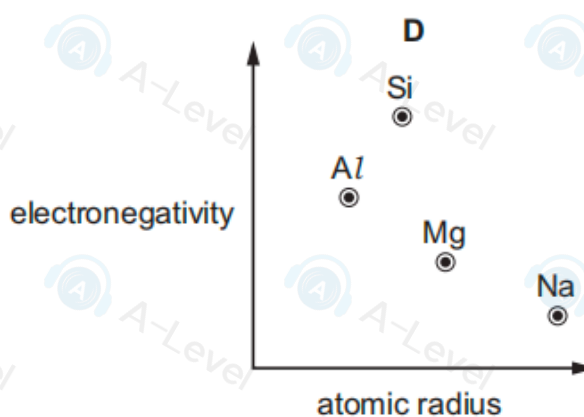
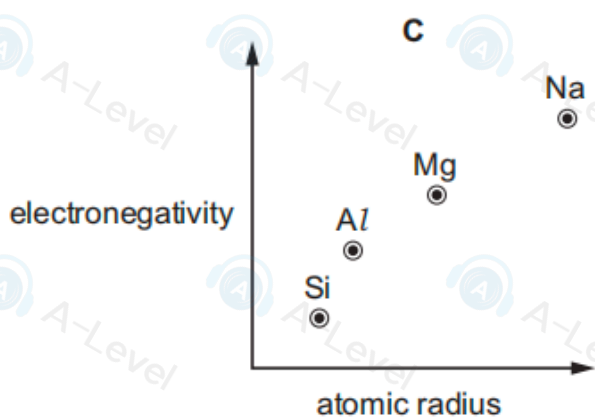
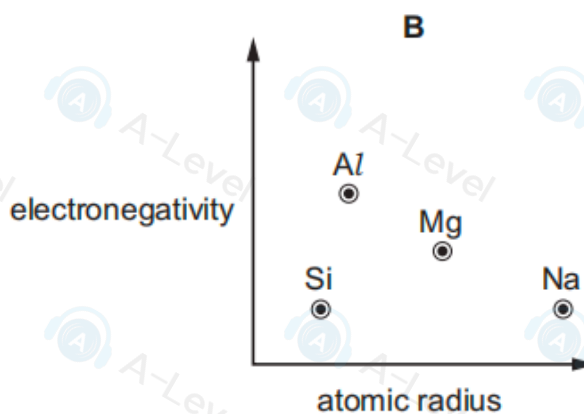
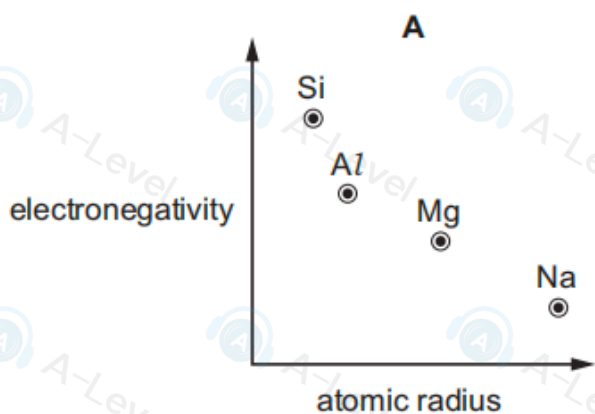
39 Which of the reactions give products containing a chiral centre?

- 1 $CH_2(OH)COCO_2H +$ an excess of HCN
- 2 $CH_2(OH)COCO_2H +$ an excess of $NaBH_4$
- 3 $CH_2(OH)COCO_2H +$ an excess of $LiAlH_4$

38 How many esters with the molecular formula $C_5H_{10}O_2$ can be made by reacting a primary alcohol with a carboxylic acid?

- A 4 B 5 C 6 D 8

19 Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



5 Flask Q contains 5 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

- A 8 kPa B 9 kPa C 10 kPa D 11 kPa

21 Which statement comparing magnesium and barium, or their compounds, is correct?

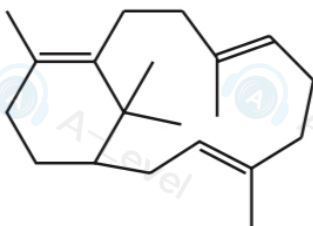
- A Magnesium reacts with dilute hydrochloric acid more rapidly than barium does.
- B One mole of magnesium carbonate gives off a greater amount of gas when it reacts with an excess of dilute hydrochloric acid than one mole of barium carbonate does.
- C The solubility of magnesium sulfate in water is greater than the solubility of barium sulfate in water.
- D Magnesium carbonate undergoes thermal decomposition **less** readily than barium carbonate does.

- 2 Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^2 4p^3$?

	Group	Period
A	13	3
B	13	4
C	15	3
D	15	4

- 20 Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

compound P



What is the number of chiral carbon atoms in the product Q?

- A** 4 **B** 5 **C** 6 **D** 7