



National  
Qualifications  
2022

**X813/77/02**

**Chemistry**  
**Section 1 — Questions**

FRIDAY, 29 APRIL

9:00 AM – 12:00 NOON

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X813/77/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



SECTION 1 — 25 marks

Attempt ALL questions

1. Which of the following statements about atomic emission spectroscopy is **not** correct?
  - A Each element has a characteristic spectrum.
  - B Visible light is used to promote electrons to higher energy levels.
  - C The lines arise from electron transitions between one energy level and another.
  - D The quantity of the element can be determined from the intensity of the radiation emitted.
  
2. How many electrons are there in the highest energy subshell of a  $\text{Cr}^+$  ion, in its ground state?
  - A 1
  - B 2
  - C 4
  - D 5
  
3. The formula of an octahedral complex ion containing a metal ion,  $\text{M}^{2+}$ , and the bidentate ligand,  $\text{L}^-$ , is:
  - A  $[\text{ML}_2]^-$
  - B  $[\text{ML}_2]^{2+}$
  - C  $[\text{ML}_3]^{2+}$
  - D  $[\text{ML}_3]^-$
  
4. Which of the following statements about heterogeneous catalysts is **not** correct?
  - A They are found in the same state as their reactants.
  - B They adsorb reactive molecules onto their active sites.
  - C They provide reaction pathways with lower activation energies.
  - D They have unpaired d electrons that allow activated complexes to form.

5. A disproportionation reaction is a redox reaction in which an element in a single substance is both oxidised and reduced.

In which of the following does a halogen undergo disproportionation?

- A  $\text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2$   
 B  $\text{IO}_3^- + 5\text{I}^- + 6\text{H}^+ \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$   
 C  $\text{I}_2 + 6\text{H}_2\text{O} + 5\text{Cl}_2 \rightarrow 2\text{HIO}_3 + 10\text{HCl}$   
 D  $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$

6. Which of the following is true for a neutral solution at 325 K?

- A  $\text{pH} = 7.00$   
 B  $K_w = 1.01 \times 10^{-14}$   
 C  $[\text{H}_3\text{O}^+] = [\text{OH}^-]$   
 D  $[\text{H}_3\text{O}^+] = 1.00 \times 10^{-7}$

7.  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -196 \text{ kJ mol}^{-1}$

Which line in the table is correct for the concentration of  $\text{SO}_3(\text{g})$  at equilibrium and the equilibrium constant,  $K$ , when the pressure of the equilibrium mixture is increased at constant temperature?

	$[\text{SO}_3(\text{g})]$ at equilibrium	Equilibrium constant, $K$
A	increase	no change
B	increase	increase
C	no change	increase
D	no change	no change

8. The standard enthalpy of formation of sodium chloride is represented by:

- A  $\text{Na}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{Na}^+\text{Cl}^-(\text{g})$   
 B  $\text{Na}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{Na}^+\text{Cl}^-(\text{s})$   
 C  $\text{Na}(\text{s}) + \text{Cl}(\text{g}) \rightarrow \text{Na}^+\text{Cl}^-(\text{s})$   
 D  $\text{Na}(\text{s}) + \frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Na}^+\text{Cl}^-(\text{s})$

[Turn over

9. The rate equation for a reaction is

$$\text{rate} = k[\text{A}]^2[\text{B}]$$

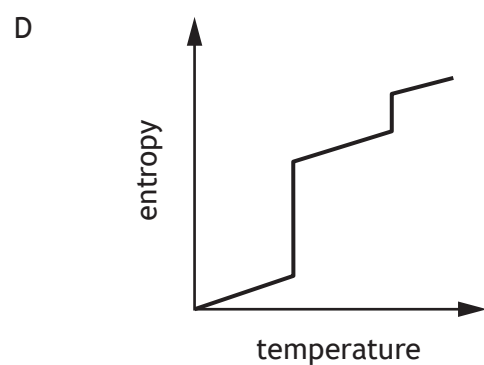
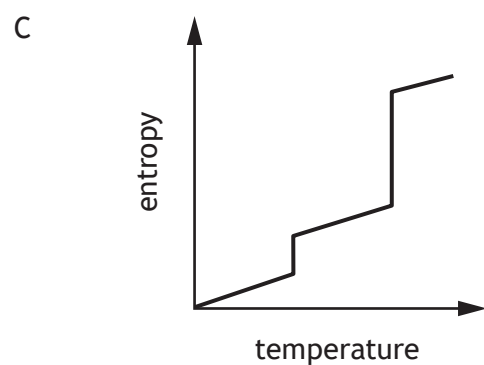
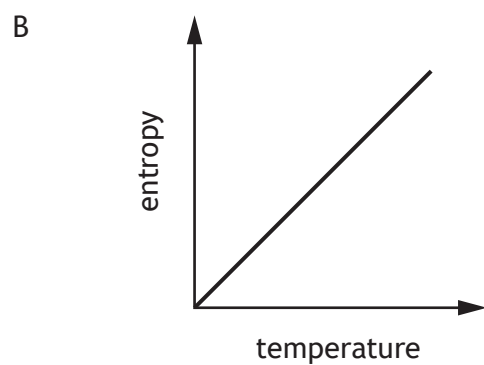
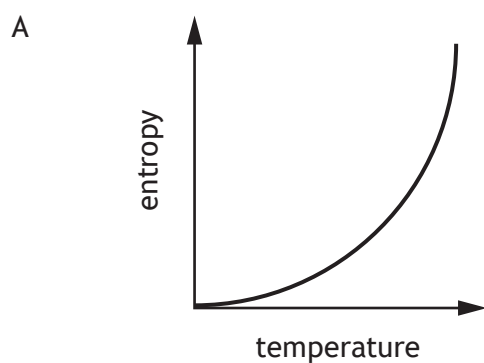
Which of the following statements is correct for this reaction?

- A Doubling the concentration of A will double the reaction rate.
- B Doubling the concentration of B will double the reaction rate.
- C Doubling the concentration of B will have no effect on the reaction rate.
- D Doubling the concentration of A and B will have no effect on the reaction rate.

10. The order of a reaction:

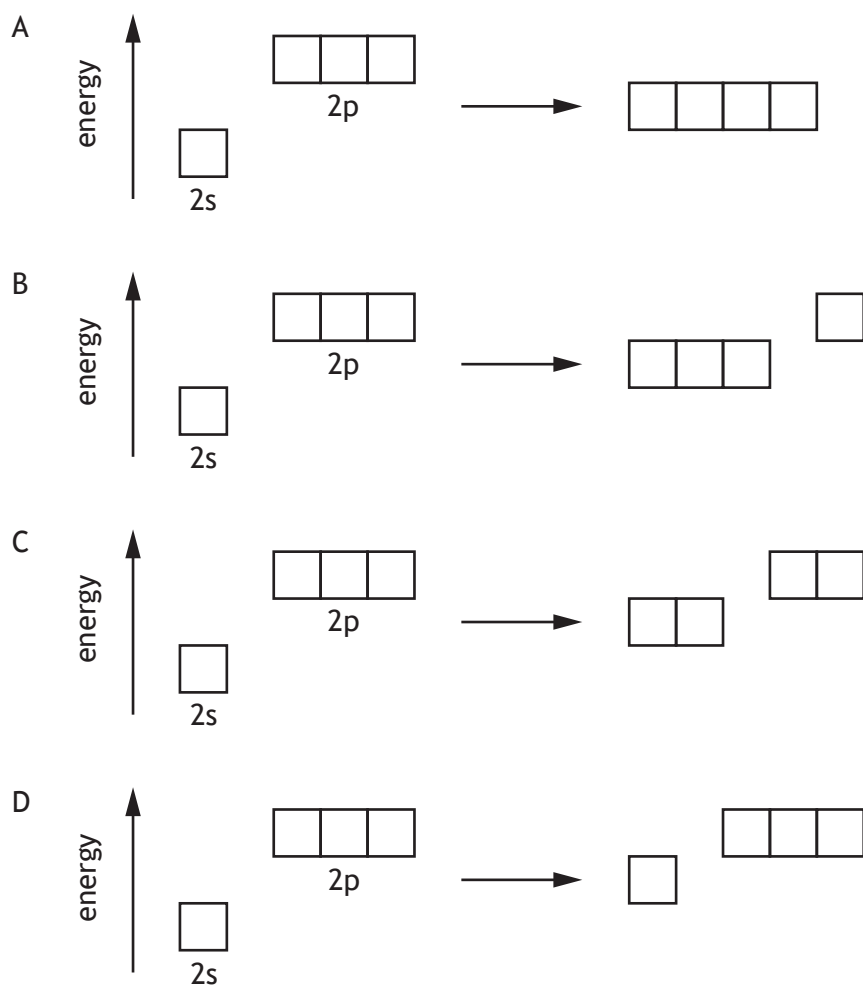
- A depends on the stoichiometry of the overall reaction
- B is the sequence of steps in the mechanism
- C controls the speed of the overall reaction
- D can only be obtained by experiment.

11. Which of the following graphs shows the variation in entropy,  $S$ , as a substance is heated from below its melting point to above its boiling point?



[Turn over

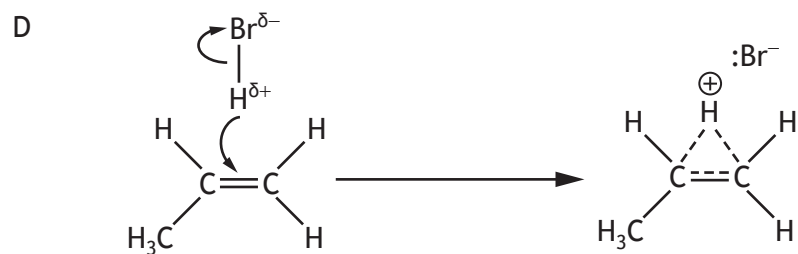
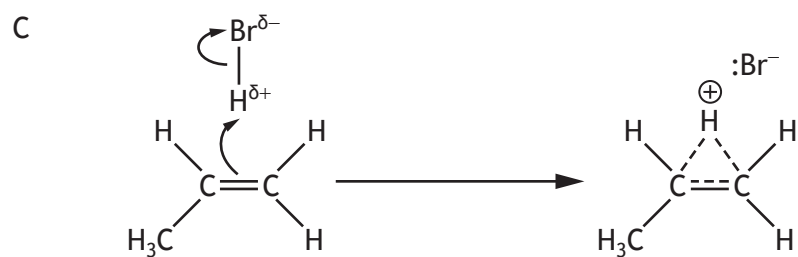
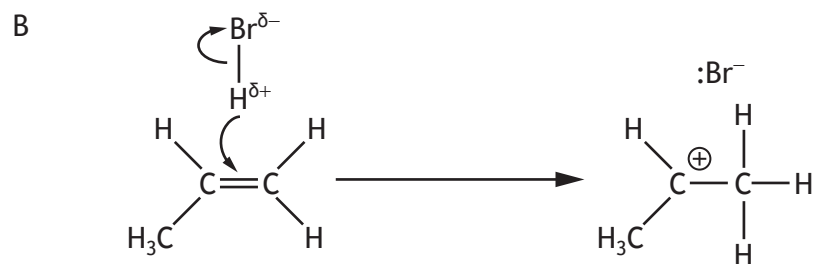
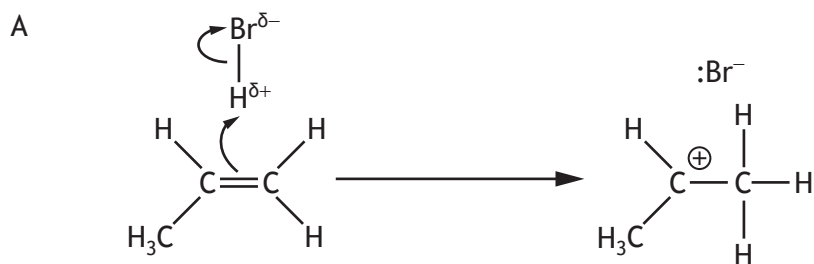
12. Which of the following diagrams represents the hybridisation of orbitals in a carbon atom of ethyne?



13. Which of the following molecules contains only sigma bonds?

- A  $\text{C}_2\text{H}_4$
- B  $\text{H}_2\text{O}$
- C  $\text{O}_2$
- D  $\text{N}_2$

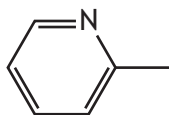
14. The addition reaction of propene and hydrogen bromide is a two-step process. Which of the following shows the first step in this mechanism?



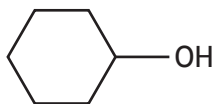
[Turn over

15. Which of the following compounds contains a phenyl group?

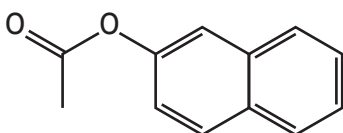
A



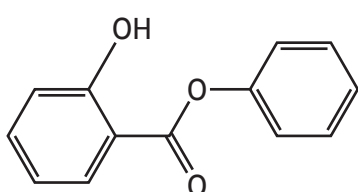
B



C



D



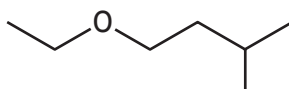
16. Consider the following reaction sequence.



Compound Y is likely to be:

- A 2-methylpropanoic acid
- B butanoic acid
- C 2-methylbutanoic acid
- D pentanoic acid.

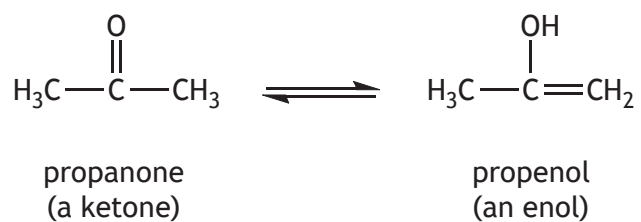
17. What is the systematic name of the molecule shown below?



- A 1-ethoxy-2-methylpropane
- B 1-ethoxy-3-methylbutane
- C 2-ethoxy-2-methylpropane
- D 2-ethoxy-3-methylbutane



18. When propanone dissolves in water the following equilibrium is established.



The ketone and enol are isomers and are called tautomers.

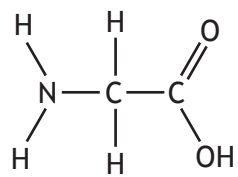
Which of the following ketones does not have an enol tautomer?

- A  $(\text{H}_3\text{C})_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$
- B  $(\text{H}_3\text{C})_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2\text{CH}_3$
- C  $(\text{H}_3\text{C})_2\text{HC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{C}(\text{CH}_3)_3$
- D  $(\text{H}_3\text{C})_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{C}(\text{CH}_3)_3$

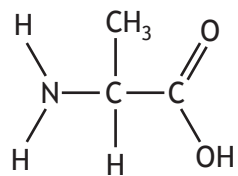
[Turn over

19. Which of the following compounds has non-superimposable mirror images?

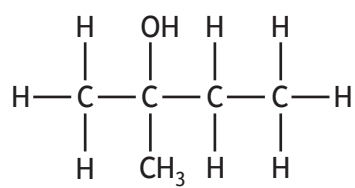
A



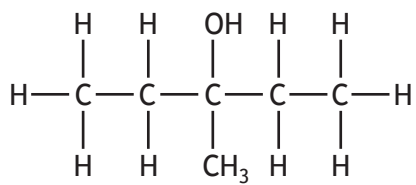
B



C

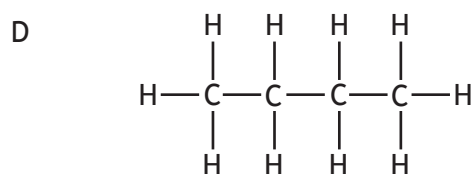
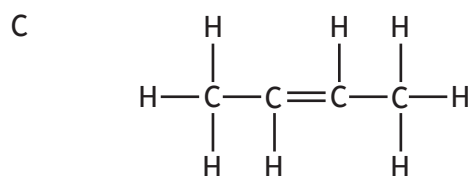
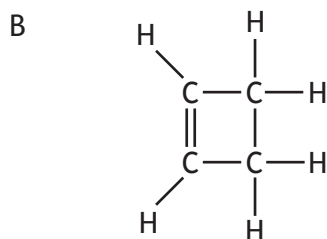
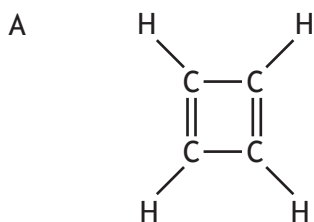


D



20. Compound X underwent elemental microanalysis and was found to contain 0.12 g of carbon and 0.02 g of hydrogen.

Compound X could be:



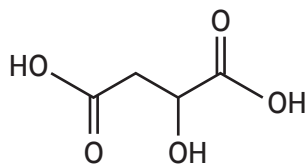
21. The mass spectrum of an organic compound had a molecular ion peak at  $m/z$  74. There were also peaks at 15, 31 and 43.

The organic compound that produced this mass spectrum is:

- A  $\text{CH}_3\text{CH}_2\text{COOH}$   
B  $\text{CH}_3\text{COOCH}_3$   
C  $\text{CH}_3\text{COCH}_2\text{CH}_3$   
D  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$

[Turn over

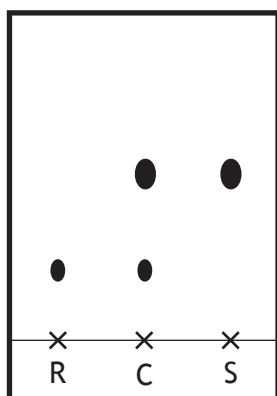
22. The structural formula of malic acid is shown below.



How many moles of sodium carbonate,  $\text{Na}_2\text{CO}_3$ , would be required to neutralise 6.7 g of malic acid ( $GFM = 134$  g)?

- A 0.050  
B 0.075  
C 0.10  
D 0.15
23. A student carried out a gravimetric analysis by heating a 2.52 g sample of hydrated calcium chloride,  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ , until it reached constant mass.
- What was the mass of the calcium chloride sample after heating to constant mass?
- A 1.70 g  
B 1.90 g  
C 2.11 g  
D 2.21 g
24. Which of the following techniques can be used to both purify and identify a compound?
- A Distillation  
B Recrystallisation  
C Solvent extraction  
D Melting point determination

25. The progress of a reaction was followed by periodically sampling the reaction mixture and analysing it using thin-layer chromatography. The chromatogram for the analysis of one sample is shown.



R is a spot of pure reactant

C is a co-spot of pure reactant and the reaction mixture sample

S is a spot of the reaction mixture sample

Which of the following conclusions **must** be correct for this thin-layer chromatogram?

- A The reaction mixture does not contain impurities.
- B All of the reactant has been used up.
- C Only the desired product is present.
- D The reaction is complete.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF  
YOUR QUESTION AND ANSWER BOOKLET.]

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE