



National  
Qualifications  
2025

**X813/77/02**

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

THURSDAY, 1 MAY

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.

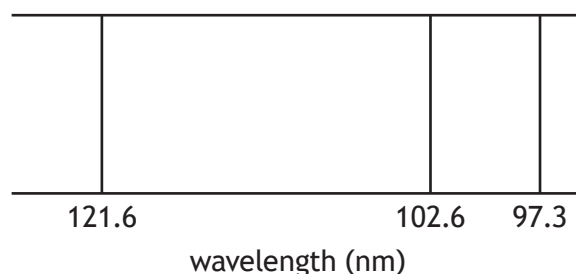


\* X 8 1 3 7 7 0 2 \*

SECTION 1 — 25 marks

Attempt ALL questions

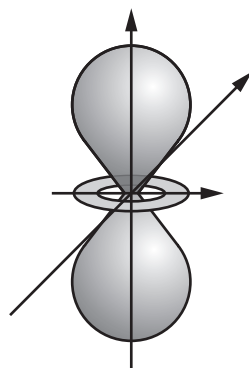
1. The diagram shows some lines in the hydrogen emission spectrum.



Each line in the emission spectrum

- A results from an excited electron dropping to a lower energy level
- B lies within the visible part of the electromagnetic spectrum
- C results from an electron moving to a higher energy level
- D represents an energy level within a hydrogen atom.

2.



The diagram above represents the shape of

- A any p orbital
- B a specific p orbital
- C any d orbital
- D a specific d orbital.

3. An ion,  $X^{3+}$ , contains 55 electrons.

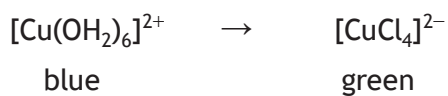
In which block of the periodic table would element X be found?

- A s
- B p
- C d
- D f

4. Which line in the table is correct for a sulfur tetrafluoride,  $SF_4$ , molecule?

|   | Number of electron pairs around sulfur | Shape adopted by electron pairs around sulfur |
|---|--|---|
| A | 4                                      | trigonal bipyramidal                          |
| B | 5                                      | trigonal bipyramidal                          |
| C | 4                                      | tetrahedral                                   |
| D | 5                                      | tetrahedral                                   |

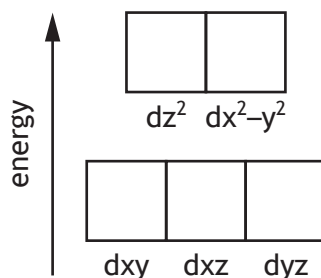
5. Which line in the table shows the changes that occur during the reaction below?



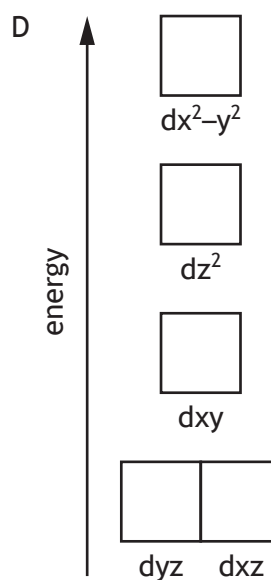
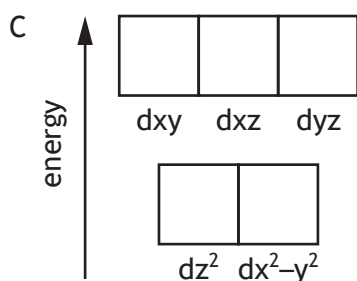
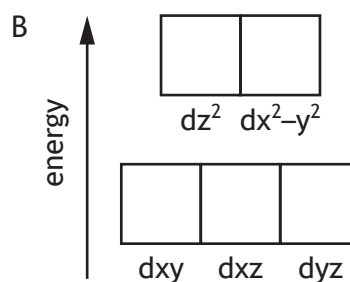
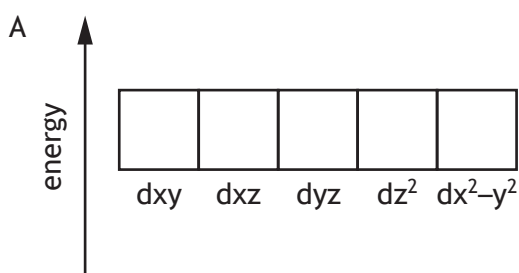
|   | Change in energy of light absorbed | Change in splitting of d orbitals |
|---|------------------------------------|-----------------------------------|
| A | increases                          | increases                         |
| B | increases                          | decreases                         |
| C | decreases                          | increases                         |
| D | decreases                          | decreases                         |

[Turn over

6. In transition metal complexes, the d subshell is split into orbitals of higher and lower energies due to repulsion between electrons in ligands and electrons in d orbitals.
- In an octahedral complex, the ligands lie along the axes. The splitting that occurs is shown.



In tetrahedral complexes, the ligands lie between the axes. The likely energies of the d orbitals in a tetrahedral complex are



7. Which line in the table is correct for the oxidation numbers of sulfur?

|   | Oxidation number of sulfur in $S_8$ | Oxidation number of sulfur in $Na_2S_2O_3$ |
|---|-------------------------------------|--|
| A | 0                                   | +2   |
| B | 0                                   | +4   |
| C | +8                                  | +2   |
| D | +8                                  | +4   |

8. The Brønsted-Lowry definition of a base is a substance which acts as a

- A proton donor to form a conjugate acid
- B proton donor to form a conjugate base
- C proton acceptor to form a conjugate acid
- D proton acceptor to form a conjugate base.

9. The pH of a buffer solution prepared by mixing equal volumes of  $0.100 \text{ mol l}^{-1}$  butanoic acid and  $0.200 \text{ mol l}^{-1}$  sodium butanoate is

- A 0.30
- B 2.92
- C 4.53
- D 5.13

10. Which salt solution would have the lowest pH?

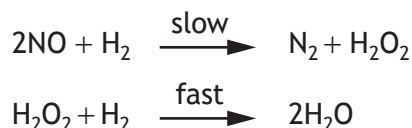
- A NaCl
- B  $Na_2CO_3$
- C  $Na_2SO_3$
- D  $CH_3COONa$

[Turn over

11. Which line in the table correctly describes the properties of  $0.1 \text{ mol l}^{-1}$  ethanoic acid when compared to  $0.1 \text{ mol l}^{-1}$  hydrochloric acid?

|   | pH     | Conductivity | Rate of reaction with magnesium |
|---|--------|--------------|---------------------------------|
| A | lower  | higher       | faster                          |
| B | higher | lower        | slower                          |
| C | higher | lower        | faster                          |
| D | lower  | higher       | slower                          |

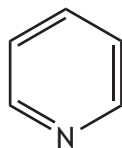
12. The reaction between nitrogen monoxide and hydrogen occurs by the following mechanism.



The overall order of this reaction is

- A 2  
B 3  
C 4  
D 5
13. Which of the following equations correctly represents the standard enthalpy of formation of calcium nitrate at 298 K?
- A  $\text{Ca(s)} + 2\text{N(g)} + 6\text{O(g)} \rightarrow \text{Ca(NO}_3)_2\text{(s)}$   
B  $\text{Ca(g)} + 2\text{N(g)} + 6\text{O(g)} \rightarrow \text{Ca(NO}_3)_2\text{(s)}$   
C  $\text{Ca(g)} + \text{N}_2\text{(g)} + 3\text{O}_2\text{(g)} \rightarrow \text{Ca(NO}_3)_2\text{(s)}$   
D  $\text{Ca(s)} + \text{N}_2\text{(g)} + 3\text{O}_2\text{(g)} \rightarrow \text{Ca(NO}_3)_2\text{(s)}$
14. Which of the following reactions will have a positive  $\Delta S^\circ$  value?
- A  $2\text{H}_2\text{(g)} + \text{C}_2\text{H}_2\text{(g)} \rightarrow \text{C}_2\text{H}_6\text{(g)}$   
B  $\text{C}_2\text{H}_4\text{(g)} + \text{Br}_2\text{(l)} \rightarrow \text{C}_2\text{H}_4\text{Br}_2\text{(l)}$   
C  $\text{LiH(s)} + \text{H}_2\text{O(l)} \rightarrow \text{LiOH(aq)} + \text{H}_2\text{(g)}$   
D  $\text{Ca(OH)}_2\text{(aq)} + \text{CO}_2\text{(g)} \rightarrow \text{CaCO}_3\text{(s)} + \text{H}_2\text{O(l)}$

15. Pyridine has the following structure.



The number of  $\sigma$  bonds in a molecule of pyridine is

- A 3
  - B 6
  - C 11
  - D 12
16. Which of the following statements is **not** true for both ethoxyethane and butan-1-ol?
- A They can both be made by nucleophilic substitution from a haloalkane.
  - B They both have hydrogen bonds between their molecules.
  - C They both have the same gram formula mass.
  - D They are both flammable.

[Turn over

17. Which of the following shows two molecules that can both be classed as tertiary?

- A
- $$\begin{array}{cccc}
 \text{H} & \text{Br} & \text{H} & \text{H} \\
 | & | & | & | \\
 \text{H}-\text{C}- & \text{C}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | & | \\
 \text{H} & \text{CH}_3 & \text{H} & \text{H}
 \end{array}$$

$$\begin{array}{cccc}
 \text{H} & & \text{H} & \text{H} \\
 | & & | & | \\
 \text{H}-\text{C}- & \text{N}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | & | \\
 \text{H} & \text{C}_2\text{H}_5 & \text{H} & \text{H}
 \end{array}$$
- B
- $$\begin{array}{ccc}
 \text{H} & \text{CH}_3 & \text{H} \\
 | & | & | \\
 \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | \\
 \text{H} & \text{NH}_2 & \text{H}
 \end{array}$$

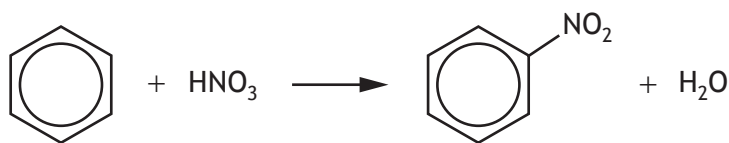
$$\begin{array}{ccc}
 \text{H} & \text{CH}_3 & \text{H} \\
 | & | & | \\
 \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | \\
 \text{H} & \text{Br} & \text{H}
 \end{array}$$
- C
- $$\begin{array}{cccc}
 \text{H} & \text{H} & \text{CH}_3 & \text{H} \\
 | & | & | & | \\
 \text{H}-\text{C}- & \text{C}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | & | \\
 \text{H} & \text{H} & \text{CH}_2\text{Br} & \text{H}
 \end{array}$$

$$\begin{array}{cccc}
 \text{H} & \text{H} & & \text{H} \\
 | & | & & | \\
 \text{H}-\text{C}- & \text{C}- & \text{N}- & \text{C}-\text{H} \\
 | & | & | & | \\
 \text{H} & \text{H} & \text{CH}_3 & \text{H}
 \end{array}$$
- D
- $$\begin{array}{ccc}
 \text{H} & & \text{H} \\
 | & & | \\
 \text{H}-\text{C}- & \text{N}- & \text{C}-\text{H} \\
 | & | & | \\
 \text{H} & \text{H} & \text{H}
 \end{array}$$

$$\begin{array}{cccc}
 \text{H} & \text{H} & \text{Br} & \text{H} \\
 | & | & | & | \\
 \text{H}-\text{C}- & \text{C}- & \text{C}- & \text{C}-\text{H} \\
 | & | & | & | \\
 \text{H} & \text{H} & \text{H} & \text{H}
 \end{array}$$



18.

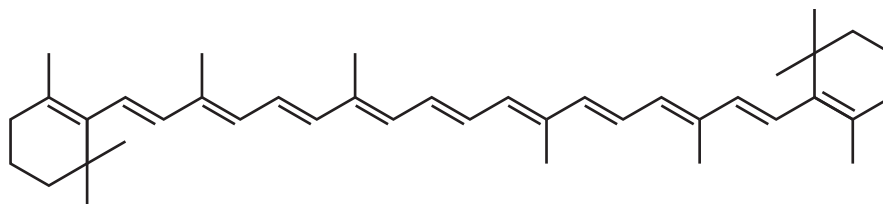


In this reaction

- A addition takes place
  - B  $\text{NO}_3^-$  acts as a nucleophile
  - C  $\text{NO}_2^+$  acts as an electrophile
  - D benzene acts as an electrophile.
19. Geometric isomers
- A are mirror images of each other
  - B always contain a carbon-carbon double bond
  - C have the same physical and chemical properties
  - D have two different groups attached to each of the carbon atoms of the bond with restricted rotation.
20. Which of the following aqueous solutions contains the greatest number of negatively charged ions?
- A  $200 \text{ cm}^3$   $0.12 \text{ mol l}^{-1}$  FeCl3(aq)
  - B  $300 \text{ cm}^3$   $0.15 \text{ mol l}^{-1}$  KI(aq)
  - C  $400 \text{ cm}^3$   $0.10 \text{ mol l}^{-1}$  Zn(NO3)2(aq)
  - D  $500 \text{ cm}^3$   $0.10 \text{ mol l}^{-1}$  Na2SO4(aq)
21. Which type of electromagnetic radiation is absorbed to produce a  $^1\text{H}$  NMR spectrum?
- A Radio waves
  - B Ultraviolet
  - C Infrared
  - D Visible

[Turn over

22. Which of the following could be used as a primary standard in the standardisation of a solution of dilute hydrochloric acid?
- A Sodium hydroxide  
B Sodium carbonate  
C Potassium dichromate  
D Potassium hydrogen phthalate
23. The melting point of an impure substance was determined to be 132°C – 135°C. After purification, the melting point was
- A lower and over a wider range  
B lower and over a narrower range  
C higher and over a wider range  
D higher and over a narrower range.
24. The concentration of an orange solution of carotene was determined by colorimetry.



An appropriate filter was selected and a blank determination carried out using the solvent only.

Which line in the table shows an appropriate filter and solvent for this colorimetric determination?

|   | Colour of filter | Solvent for blank determination |
|---|------------------|---------------------------------|
| A | green-blue       | water                           |
| B | green-blue       | hexane                          |
| C | orange           | water                           |
| D | orange           | hexane                          |

25. The process of recrystallisation is described by the following steps.
1. Dissolve the impure sample in a minimum volume of hot solvent.
  2. Carry out hot filtration of the resulting mixture.
  3. Cool the filtrate slowly to allow crystals to form.
  4. Filter, wash and dry the pure crystals.

Which line in the table correctly identifies the steps at which the insoluble and soluble impurities are removed?

|   | Removal of insoluble impurities | Removal of soluble impurities |
|---|---------------------------------|-------------------------------|
| A | 2                               | 1                             |
| B | 3                               | 2                             |
| C | 2                               | 4                             |
| D | 4                               | 2                             |

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

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