



Chemistry Standard Level

Paper 1A — Mock Examination

Mock Exam 1

Calculator required

Time allowed: **50 minutes**

Maximum mark: **30 marks**

Candidate information

Candidate name:

Session number:

Date:

Topic emphasis: the particulate nature of matter and quantitative chemistry, atomic structure and emission spectra, models of bonding and structure, classification of matter and periodicity, energetics and fuels, rates of reaction, chemical equilibrium, proton transfer and electron transfer reactions, and the reactivity of organic compounds. Questions are distributed across Structure 1–3 and Reactivity 1–3 of the syllabus.

Instructions to candidates

- Write your session number in the box on the cover.
- Do not open this examination paper until you are told to do so.
- Answer **all** questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

Each question is worth one mark. There is no negative marking. Values of constants, molar masses and relative atomic masses should be taken from the chemistry data booklet unless they are given in the question. Unless otherwise stated, all measurements were made at 298 K and 100 kPa.

Mark allocation

Questions 1–6	Structure 1: models of the particulate nature of matter	[6 marks]
Questions 7–10	Structure 2: models of bonding and structure	[4 marks]
Questions 11–15	Structure 3: classification of matter	[5 marks]
Questions 16–18	Reactivity 1: what drives chemical reactions?	[3 marks]
Questions 19–21	Quantitative chemistry: limiting reactant, yield and atom economy	[3 marks]
Questions 22–24	Reactivity 2: how fast and how far?	[3 marks]
Questions 25–30	Reactivity 3: what are the mechanisms of chemical change?	[6 marks]
Total		[30 marks]

Section A

Answer all questions. For each question choose the answer you consider to be the best.

1. Which assumptions are made in the kinetic molecular theory of an ideal gas?

- I. The volume occupied by the particles themselves is negligible.
- II. Collisions between the particles are perfectly elastic.
- III. There are no attractive forces between the particles.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

2. What are the numbers of subatomic particles in $^{81}\text{Se}^{2-}$?

	Protons	Neutrons	Electrons
A.	34	47	32
B.	34	47	36
C.	34	81	36
D.	36	45	34

3. Which quantity can be determined directly from the convergence limit of the lines in the ultraviolet series of the hydrogen emission spectrum?

- A. The energy of the $n = 2$ level of hydrogen
- B. The bond enthalpy of the H–H bond
- C. The first ionization energy of hydrogen
- D. The relative atomic mass of hydrogen

4. What is the ground state electron configuration of the Fe^{2+} ion?

- A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
- B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$
- C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
- D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$

5. 5.08 g of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ ($M_r = 203.3 \text{ g mol}^{-1}$) is dissolved in water and made up to 250.0 cm^3 of solution.

What is the concentration of chloride ions, in mol dm^{-3} , in the resulting solution?

- A. 0.050
- B. 0.10
- C. 0.20
- D. 0.40

6. A sample of an ideal gas occupies 2.00 dm^3 at 27°C and 150 kPa . The sample is transferred to a sealed 1.50 dm^3 container and cooled to -23°C .

What is the new pressure, in kPa ?

- A. 125
- B. 167
- C. 180
- D. 240

7. Which species has one non-bonding (lone) pair on the central atom and bond angles of approximately 107° ?

- A. BF_3
- B. CH_4
- C. H_2O
- D. H_3O^+

8. What are the electron domain geometry and the molecular geometry of the sulfite ion, SO_3^{2-} ?

	Electron domain geometry	Molecular geometry
A.	Tetrahedral	Trigonal pyramidal
B.	Tetrahedral	Trigonal planar
C.	Trigonal planar	Trigonal planar
D.	Trigonal planar	Bent

9. In which pair is hydrogen bonding the strongest intermolecular force present in **both** substances?

- A. CH_3OCH_3 and $\text{CH}_3\text{CH}_2\text{OH}$
- B. HCl and H_2S
- C. CH_3COOH and NH_3
- D. CH_3CHO and $(\text{CH}_3)_3\text{N}$

10. Silicon dioxide melts at about 1700°C whereas solid carbon dioxide changes to a gas at -78°C .

Which statement explains this difference?

- A. SiO_2 contains ionic bonds whereas CO_2 contains covalent bonds.
- B. The $\text{Si}-\text{O}$ bond is stronger than the $\text{C}=\text{O}$ bond.
- C. SiO_2 is a covalent network, so covalent bonds must be broken, whereas only London (dispersion) forces are overcome in CO_2 .
- D. CO_2 molecules are non-polar whereas SiO_2 molecules are polar.

11. Why is the first ionization energy of sulfur lower than that of phosphorus?

- A. In sulfur the electron removed is one of a pair occupying the same $3p$ orbital, so there is greater repulsion.
- B. Sulfur has a smaller nuclear charge than phosphorus.
- C. Sulfur has a larger atomic radius than phosphorus.
- D. The $3p$ sub-level of phosphorus is full.

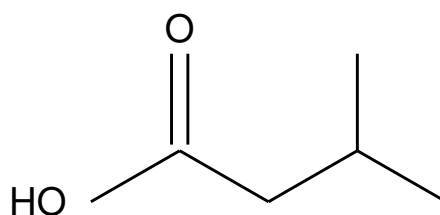
12. Which oxide reacts with both dilute hydrochloric acid and aqueous sodium hydroxide?

- A. Na_2O
- B. MgO
- C. Al_2O_3
- D. SO_2

13. Which reaction occurs when the aqueous solutions are mixed?

- A. $\text{Br}_2(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \longrightarrow 2 \text{Br}^-(\text{aq}) + \text{Cl}_2(\text{aq})$
- B. $\text{I}_2(\text{aq}) + 2 \text{Br}^-(\text{aq}) \longrightarrow 2 \text{I}^-(\text{aq}) + \text{Br}_2(\text{aq})$
- C. $\text{Cl}_2(\text{aq}) + 2 \text{I}^-(\text{aq}) \longrightarrow 2 \text{Cl}^-(\text{aq}) + \text{I}_2(\text{aq})$
- D. $\text{Br}_2(\text{aq}) + 2 \text{F}^-(\text{aq}) \longrightarrow 2 \text{Br}^-(\text{aq}) + \text{F}_2(\text{aq})$

14. What is the IUPAC name of the compound below?



- A. 2-methylbutanoic acid
- B. 3-methylbutanoic acid
- C. 4-methylbutanoic acid
- D. 2,2-dimethylpropanoic acid

15. Which formula represents a secondary alcohol?

- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- B. $(\text{CH}_3)_3\text{COH}$
- C. $\text{CH}_3\text{OCH}_2\text{CH}_3$
- D. $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

16. 1.00 g of a liquid fuel was burned completely and all the heat released was transferred to 200.0 g of water, raising its temperature by 12.0 °C. The specific heat capacity of water is 4.18 J g⁻¹ K⁻¹.

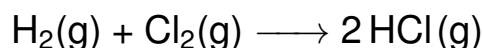
What is the energy released per gram of fuel, in kJ g⁻¹?

- A. 2.51
- B. 10.0
- C. 100
- D. 1003

17. Consider the following average bond enthalpies.

Bond	Bond enthalpy / kJ mol ⁻¹
H–H	436
Cl–Cl	242
H–Cl	431

What is ΔH , in kJ mol⁻¹, for the reaction below?

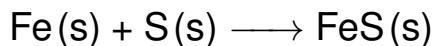


- A. +184
- B. –184
- C. +247
- D. –247

18. Which statement about the combustion of fossil fuels is correct?

- A. Incomplete combustion of hydrocarbons produces carbon monoxide, which is toxic.
- B. Complete combustion of a pure hydrocarbon produces sulfur dioxide.
- C. Carbon dioxide released during combustion is the main cause of acid deposition.
- D. Oxides of nitrogen are formed from nitrogen atoms contained within the fuel molecules.

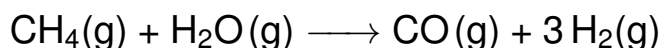
19. 5.00 g of iron is heated with 5.00 g of sulfur until reaction is complete.



What is the maximum mass, in g, of iron(II) sulfide that can be formed? (A_r : Fe = 55.85, S = 32.07)

- A. 5.00
- B. 7.87
- C. 10.0
- D. 13.7

20. Hydrogen is manufactured by steam reforming of methane.



What is the percentage atom economy for the production of hydrogen?

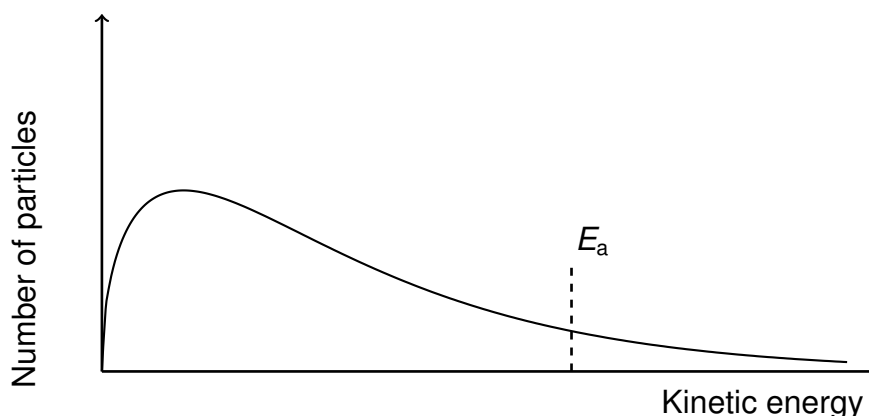
- A. 17.8 %
- B. 21.6 %
- C. 33.3 %
- D. 82.2 %

21. An excess of magnesium ribbon is added to 50.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid at 25 °C.

Which change increases the initial rate of reaction but does **not** change the total volume of hydrogen produced?

- A. Using 100.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid
- B. Using 50.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid
- C. Using the same mass of magnesium as a fine powder
- D. Adding 50.0 cm³ of water to the acid before adding the magnesium

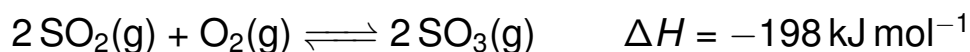
- 22.** The Maxwell–Boltzmann energy distribution for a reaction mixture at constant temperature is shown.



Which statement describes the effect of adding a catalyst at the same temperature?

- A. The whole curve shifts towards higher kinetic energies.
- B. The total area under the curve increases.
- C. A greater proportion of the particles has energy greater than or equal to the activation energy.
- D. The average kinetic energy of the particles increases.

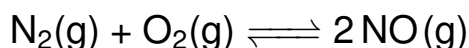
- 23.** Consider the equilibrium below.



Which change increases the equilibrium yield of SO_3 ?

- A. Increasing the temperature at constant pressure
- B. Increasing the pressure at constant temperature
- C. Adding a catalyst
- D. Increasing the volume of the container at constant temperature

24. At a particular temperature the equilibrium constant for the reaction below is $K = 2.0 \times 10^{-5}$.



What can be deduced about the equilibrium mixture at this temperature?

- A. The equilibrium is reached very slowly.
 - B. The mixture contains mainly NO.
 - C. The forward reaction is exothermic.
 - D. The mixture contains mainly N_2 and O_2 .
25. Which species can act as **both** a Brønsted–Lowry acid and a Brønsted–Lowry base?
- I. HCO_3^-
 - II. H_2O
 - III. NH_4^+
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
26. What is the pH of $0.0500 \text{ mol dm}^{-3} \text{ Ba(OH)}_2(\text{aq})$ at 298 K?
- $\text{pH} = -\log_{10}[\text{H}^+]$ $K_w = [\text{H}^+][\text{OH}^-] = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$
- A. 1.00
 - B. 1.30
 - C. 12.70
 - D. 13.00
27. What is the oxidation state of sulfur in the thiosulfate ion, $\text{S}_2\text{O}_3^{2-}$?
- A. +2
 - B. +3
 - C. +4
 - D. +6

28. What is the correct half-equation for the reduction of the dichromate(VI) ion in acidic solution?

- A. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
- B. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
- C. $\text{Cr}_2\text{O}_7^{2-} + 7\text{H}_2\text{O} + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 14\text{OH}^-$
- D. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{e}^-$

29. Molten lead(II) bromide is electrolysed using inert electrodes.

What happens at the negative electrode?

- A. Bromide ions are oxidized to bromine.
- B. Lead(II) ions are reduced to lead.
- C. Lead(II) ions are oxidized to lead.
- D. Bromine is reduced to bromide ions.

30. 2-bromopropane is warmed with aqueous sodium hydroxide.

What are the type of reaction and the organic product?

	Type of reaction	Organic product
A.	Nucleophilic substitution	Propan-2-ol
B.	Nucleophilic substitution	Propan-1-ol
C.	Elimination	Propene
D.	Free-radical substitution	Propan-2-ol

End of examination.

Total: 30 marks