



Chemistry

Higher Level

Paper 1A — Mock Examination

Mock Exam 1

Calculator required

Time allowed: **1 hour 5 minutes**

Maximum mark: **40 marks**

Candidate information

Candidate name:

Session number:

Date:

Topic emphasis: models of the particulate nature of matter, models of bonding and structure, classification of matter, what drives chemical reactions, how much / how fast / how far, and what are the mechanisms of chemical change.

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 **[40 marks]**.

The mark allocation is shown in square brackets at the end of each question; every question in this paper is worth **one mark [1]**. There is no penalty for an incorrect answer, so you should attempt every question. Where a numerical answer is required, values of constants and molar masses should be taken from the chemistry data booklet unless they are given in the question.

Take the molar volume of an ideal gas at STP to be $22.7 \text{ dm}^3 \text{ mol}^{-1}$ and the ideal gas constant to be $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$. All questions refer to standard conditions and to a temperature of 298 K unless otherwise stated.

Mark allocation

Section A (questions 1–20) [20 marks]

Section A (questions 21–40) [20 marks]

Total [40 marks]

Section A

Answer all questions. The maximum mark for each question is given in square brackets.

1. Which change of state is exothermic? [1]
- A. Condensation
 - B. Melting
 - C. Boiling
 - D. Sublimation
2. Naturally occurring boron consists of 19.9 % of ^{10}B and 80.1 % of ^{11}B .
What is the relative atomic mass of boron? [1]
- A. 10.2
 - B. 10.5
 - C. 10.8
 - D. 11.0
3. 2.22 g of anhydrous calcium chloride, CaCl_2 ($M_r = 111$), is dissolved in water to make 500 cm^3 of solution.
What is the concentration of chloride ions, in mol dm^{-3} , in the solution? [1]
- A. 0.020
 - B. 0.040
 - C. 0.080
 - D. 0.16
4. A fixed mass of an ideal gas occupies 250 cm^3 at 27°C and 100 kPa.
What is the volume of the gas, in cm^3 , at 127°C and 50 kPa? [1]
- A. 333
 - B. 375
 - C. 500
 - D. 667

5. What is the ground state electron configuration of the Cr^{3+} ion? [1]
- A. $[\text{Ar}] 3d^5 4s^1$
B. $[\text{Ar}] 3d^5$
C. $[\text{Ar}] 3d^4$
D. $[\text{Ar}] 3d^3$
6. The first four successive ionization energies of an element, in kJ mol^{-1} , are:
738 1451 7733 10 540
In which group of the periodic table is this element? [1]
- A. 1
B. 2
C. 13
D. 14
7. Which species has the smallest radius? [1]
- A. Mg^{2+}
B. Na^+
C. F^-
D. O^{2-}
8. Which compound has the most exothermic lattice enthalpy? [1]
- A. MgO
B. CaO
C. NaCl
D. KBr
9. What are the electron domain geometry and the molecular geometry of XeF_4 ? [1]

	Electron domain geometry	Molecular geometry
A.	Tetrahedral	Tetrahedral
B.	Trigonal bipyramidal	Seesaw
C.	Octahedral	Octahedral
D.	Octahedral	Square planar

10. Which molecule contains polar bonds but is non-polar overall? [1]

- A. NH_3
- B. H_2O
- C. SO_2
- D. BF_3

11. How many σ (sigma) and π (pi) bonds are present in one molecule of propanenitrile, $\text{CH}_3\text{CH}_2\text{CN}$? [1]

	σ , sigma	π , pi
A.	6	2
B.	7	3
C.	8	2
D.	9	3

12. Which compound has the highest boiling point? [1]

- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- B. $\text{CH}_3\text{OCH}_2\text{CH}_3$
- C. CH_3COCH_3
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

13. Which statement best explains why graphene is a good electrical conductor? [1]

- A. Delocalized electrons are free to move within the layer.
- B. It has a giant covalent structure.
- C. Each carbon atom forms four single covalent bonds.
- D. It contains mobile carbon ions.

14. Which oxide forms the most acidic solution when added to water? [1]

- A. Na_2O
- B. MgO
- C. Al_2O_3
- D. P_4O_{10}

15. Which aqueous ion is colourless? [1]
- A. Zn^{2+}
 - B. Ti^{3+}
 - C. V^{3+}
 - D. Co^{2+}
16. What is the oxidation state of manganese in the MnO_4^{2-} ion? [1]
- A. +4
 - B. +5
 - C. +6
 - D. +7
17. What is the IUPAC name of $(\text{CH}_3)_2\text{CHCH}_2\text{COOH}$? [1]
- A. 2-methylbutanoic acid
 - B. 3-methylbutanoic acid
 - C. 3-methylpropanoic acid
 - D. 2,2-dimethylpropanoic acid
18. Which pair of compounds are functional group isomers? [1]
- A. Propanal and propanone
 - B. Propan-1-ol and propan-2-ol
 - C. Butane and methylpropane
 - D. But-1-ene and but-2-ene
19. Which molecule contains a chiral carbon atom? [1]
- A. $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
 - B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 - C. $(\text{CH}_3)_3\text{COH}$
 - D. $(\text{CH}_3)_2\text{CHCOOH}$

20. How many signals are present in the low-resolution ^1H NMR spectrum of ethyl ethanoate, $\text{CH}_3\text{COOCH}_2\text{CH}_3$? [1]

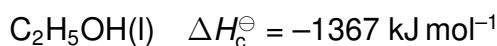
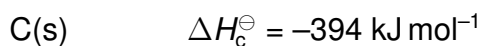
- A. 2
- B. 3
- C. 4
- D. 5

21. A compound has a molecular ion peak at $m/z = 46$ in its mass spectrum. Its infrared spectrum shows a broad absorption between 3200 and 3600 cm^{-1} and no strong absorption near 1700 cm^{-1} .

What is the compound? [1]

- A. CH_3CHO
- B. $\text{CH}_3\text{CH}_2\text{OH}$
- C. CH_3OCH_3
- D. HCOOH

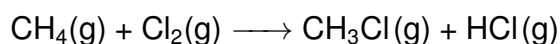
22. Consider the following standard enthalpies of combustion:



What is the standard enthalpy of formation of ethanol, in kJ mol^{-1} ? [1]

- A. -2013
- B. -1367
- C. -279
- D. $+279$

23. Use the average bond enthalpies below to estimate the enthalpy change, in kJ mol^{-1} , for the reaction:



- A. -225
- B. -99
- C. $+99$
- D. $+225$

24. Which is an advantage of using hydrogen rather than petrol as a fuel in a vehicle? [1]

- A. The only product of its combustion with oxygen is water.
- B. It is easily stored as a liquid at room temperature and pressure.
- C. It has a lower specific energy than petrol.
- D. It is obtained industrially without any energy input.

25. Which reaction has the largest positive entropy change, $\Delta S^\ominus$? [1]

- A. $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{H}_2\text{O}(\text{l})$
- B. $\text{CaCO}_3(\text{s}) \longrightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- C. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \longrightarrow 2\text{NH}_3(\text{g})$
- D. $\text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2\text{O}(\text{s})$

26. A reaction has $\Delta H^\ominus = +52 \text{ kJ mol}^{-1}$ and $\Delta S^\ominus = +145 \text{ J K}^{-1} \text{ mol}^{-1}$.

Above which temperature, in K, does the reaction become spontaneous? [1]

- A. 0.36
- B. 359
- C. 2790
- D. 7540

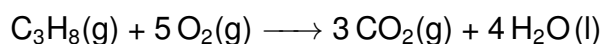
27. 5.00 g of calcium carbonate ($M_r = 100.09$) is heated and decomposes according to the equation below. The percentage yield of calcium oxide ($M_r = 56.08$) is 80.0 %.



What mass of calcium oxide, in g, is obtained? [1]

- A. 1.79
- B. 2.24
- C. 2.80
- D. 3.50

28. Propane undergoes complete combustion.



What volume of carbon dioxide, in dm^3 , is produced at STP from 0.500 mol of propane? [1]

- A. 11.4
- B. 22.7
- C. 34.1

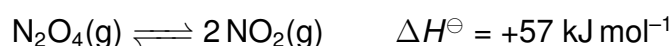
D. 45.4

29. The following data were obtained for the reaction between A and B at constant temperature. [1]

Experiment	[A] / mol dm ⁻³	[B] / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	0.10	0.10	2.0×10^{-3}
2	0.20	0.10	8.0×10^{-3}
3	0.10	0.20	4.0×10^{-3}

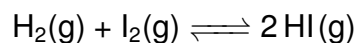
What is the rate equation for this reaction?

- A. rate = $k[A][B]$
B. rate = $k[A][B]^2$
C. rate = $k[A]^2[B]^2$
D. rate = $k[A]^2[B]$
30. The half-life of a first order reaction is 20 s.
What fraction of the original reactant remains after 60 s? [1]
- A. 1/2
B. 1/4
C. 1/8
D. 1/16
31. Which statement about a catalyst is correct? [1]
- A. It increases the average kinetic energy of the reacting particles.
B. It shifts the position of equilibrium towards the products.
C. It increases the enthalpy change of the reaction.
D. It provides an alternative pathway with a lower activation energy.
32. Consider the following equilibrium.



- Which change increases the equilibrium yield of NO₂? [1]
- A. Increasing the pressure at constant temperature
B. Decreasing the temperature at constant pressure
C. Increasing the temperature at constant pressure
D. Adding a catalyst at constant temperature and pressure

33. 1.00 mol of $\text{H}_2(\text{g})$ and 1.00 mol of $\text{I}_2(\text{g})$ were placed in a 1.00 dm^3 container. At equilibrium the mixture contained 1.56 mol of $\text{HI}(\text{g})$.



What is the value of the equilibrium constant, K ? [1]

- A. 7.1
- B. 32
- C. 50
- D. 100

34. What is the pH of $0.0100 \text{ mol dm}^{-3}$ $\text{NaOH}(\text{aq})$ at 298 K? [1]

- A. 2.00
- B. 10.00
- C. 12.00
- D. 13.00

35. The acid dissociation constant of ethanoic acid at 298 K is $K_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$.

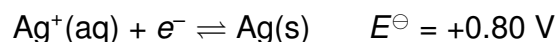
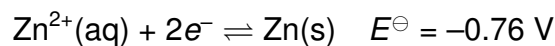
What is the pH of $0.100 \text{ mol dm}^{-3}$ ethanoic acid at 298 K? [1]

- A. 1.00
- B. 2.87
- C. 4.74
- D. 5.74

36. Which mixture forms a buffer solution? [1]

- A. Equal amounts, in mol, of $\text{HCl}(\text{aq})$ and $\text{NaCl}(\text{aq})$
- B. Equal amounts, in mol, of $\text{HCl}(\text{aq})$ and $\text{NaOH}(\text{aq})$
- C. Equal amounts, in mol, of $\text{NaOH}(\text{aq})$ and $\text{NaCl}(\text{aq})$
- D. Equal amounts, in mol, of $\text{NH}_3(\text{aq})$ and $\text{NH}_4\text{Cl}(\text{aq})$

37. Consider the standard electrode potentials below.



What are the cell potential and the sign of $\Delta G^{\ominus}$ for the voltaic cell made from these two half-cells? [1]

	Cell potential / V	Sign of $\Delta G^{\ominus}$
A.	+1.56	Negative
B.	+1.56	Positive
C.	+0.04	Negative
D.	-1.56	Positive

38. Methane reacts with chlorine in the presence of ultraviolet light.

Which equation represents a propagation step in this mechanism? [1]

- A. $\text{Cl}_2 \longrightarrow 2 \text{Cl}^{\bullet}$
- B. $\text{CH}_3^{\bullet} + \text{Cl}^{\bullet} \longrightarrow \text{CH}_3\text{Cl}$
- C. $2 \text{Cl}^{\bullet} \longrightarrow \text{Cl}_2$
- D. $\text{CH}_4 + \text{Cl}^{\bullet} \longrightarrow \text{CH}_3^{\bullet} + \text{HCl}$

39. What is the major product of the reaction between propene, $\text{CH}_3\text{CH}=\text{CH}_2$, and hydrogen bromide, HBr ? [1]

- A. 1-bromopropane
- B. 2-bromopropane
- C. 1,2-dibromopropane
- D. propan-2-ol

- 40.** Which statement about the S_N2 mechanism is correct? **[1]**
- A. The rate depends on the concentrations of both the halogenoalkane and the nucleophile.
 - B. The mechanism involves the formation of a carbocation intermediate.
 - C. The mechanism takes place in two distinct steps.
 - D. The mechanism is favoured by tertiary halogenoalkanes.

End of examination.

Total: **40 marks**

Answer sheet

Write the letter of your chosen answer in the box next to each question number.

Q	Ans		Q	Ans		Q	Ans		Q	Ans
1			11			21			31	
2			12			22			32	
3			13			23			33	
4			14			24			34	
5			15			25			35	
6			16			26			36	
7			17			27			37	
8			18			28			38	
9			19			29			39	
10			20			30			40	

Candidate name:

Session number:

Total mark: / 40