Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

8 May 2024

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[30 marks]**.

2224–6210

13 pages

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01				Atomic number **Element** Relative atomic mass							5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. Which compound has the highest percentage of carbon by mass?

A. CH_4

B. C_2H_6

C. CO

D. CO_2

2. 6.00 mol of copper, Cu, are mixed with 12.00 mol of dilute nitric acid, HNO_3 (aq). The equation for the reaction that occurs is shown below.

$$3Cu\,(s) + 8HNO_3\,(aq) \rightarrow 3Cu\,(NO_3)_2\,(aq) + 2NO\,(g) + 4H_2O\,(l)$$

What is the amount, in mol, of nitrogen(II) oxide, NO, produced assuming that the reaction goes to completion?

A. 3.00

B. 4.00

C. 8.00

D. 18.00

3. What is correct for the empirical formula of a compound?

A. The number of atoms of each element in a molecule of the compound

B. The total number of atoms in a molecule of the compound

C. The simplest ratio of atoms of each element in a molecule of the compound

D. The total number of elements in a molecule of the compound

4. What is the number of hydrogen atoms in 2.00 mol of NH_3?

Avogadro's constant (L or N_A) = $6.02 \times 10^{23}\,mol^{-1}$

A. 1.20×10^{24}

B. 1.81×10^{24}

C. 2.41×10^{24}

D. 3.61×10^{24}

5. What is the maximum number of electrons that can occupy the fourth shell in the atom ($n = 4$)?

A. 8

B. 18

C. 32

D. 36

6. How are the lines in the emission spectrum of hydrogen produced?

A. Electrons move to higher energy levels absorbing photons.

B. Electrons move to lower energy levels releasing photons.

C. Electrons move to higher energy levels releasing photons.

D. Electrons move to lower energy levels absorbing photons.

7. Which set of ions shows **increasing** ionic radii?

A. $P^{3-} < Cl^{-} < K^{+} < Ca^{2+}$

B. $Cl^{-} < P^{3-} < Ca^{2+} < K^{+}$

C. $K^{+} < Ca^{2+} < P^{3-} < Cl^{-}$

D. $Ca^{2+} < K^{+} < Cl^{-} < P^{3-}$

8. When the same amount of each oxide is added to an equal volume of water, which oxide produces the solution with the highest pH?

A. MgO

B. Al_2O_3

C. SiO_2

D. SO_2

9. What is the geometry around a carbon atom in graphene?

A. Hexagonal

B. Pyramidal

C. Tetrahedral

D. Trigonal planar

10. What is the correct number of bonding pairs of electrons in ethanedioic acid, $(COOH)_2$?

A. 7

B. 8

C. 9

D. 18

11. Which best explains the malleability of metals?

A. Delocalized electrons can move throughout the anion lattice.

B. Layers of anions are held together by delocalized electrons.

C. Non-directional bonds allow layers of cations to slide over each other.

D. The attraction between the cations and the delocalized electrons is strong.

12. Which two liquids are immiscible?

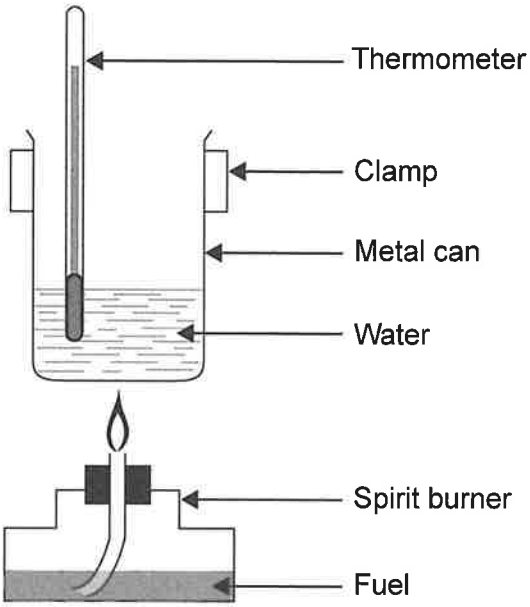
A. H_2O and $CH_3CH_2CH_2CH_2CH_2CH_2OH$

B. H_2O and CH_3COOH

C. CH_3CH_2OH and CH_3COOH

D. $CH_3CH_2CH_2CH_2CH_3$ and $CH_3CH_2CH_2CH_2CH_2CH_3$

13. A student determined the enthalpy change of combustion of a fuel by burning it in a spirit burner placed under a metal can containing 100 cm^3 of water.



Which modification can improve the accuracy of the experiment?

A. Placing a lid on the metal can containing water

B. Covering the spirit burner with aluminium foil

C. Increasing the distance between the metal can and the spirit burner

D. Using warm water instead of water at room temperature in the metal can

14. Standard enthalpy changes of reaction are provided for the following reactions.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = -394\,kJ$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^{\ominus} = -286\,kJ$$

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H^{\ominus} = -1367\,kJ$$

What is the standard enthalpy change, in kJ, of the following reaction?

$$2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$$

A. $(-394 \times 2) - (286 \times 3) - 1367$

B. $(394 \times 2) + (286 \times 3) + 1367$

C. $(394 \times 2) + (286 \times 3) - 1367$

D. $(-394 \times 2) - (286 \times 3) + 1367$

15. Which statement about a chemical reaction involving covalent molecules is correct?

A. More energy is given out if the products are in the gaseous rather than the liquid state.

B. If the products have stronger bonds than the reactants the reaction is exothermic.

C. Enthalpy change of reaction is the sum of the bond enthalpies of the products minus the sum of the bond enthalpies of the reactants.

D. Forming bonds absorbs the activation energy.

16. Which best explains the low rate of a reaction between two gases occurring at high temperature and high pressure?

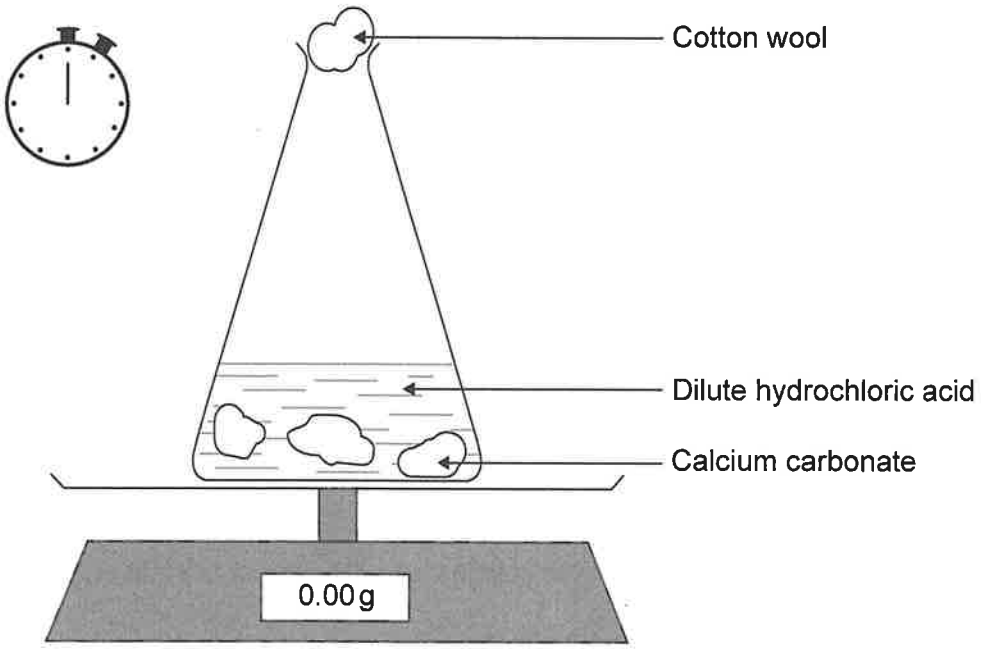
A. The frequency of collisions is low.

B. The bonds in the reactants are strong.

C. A high fraction of reactant molecules collides with the correct orientation.

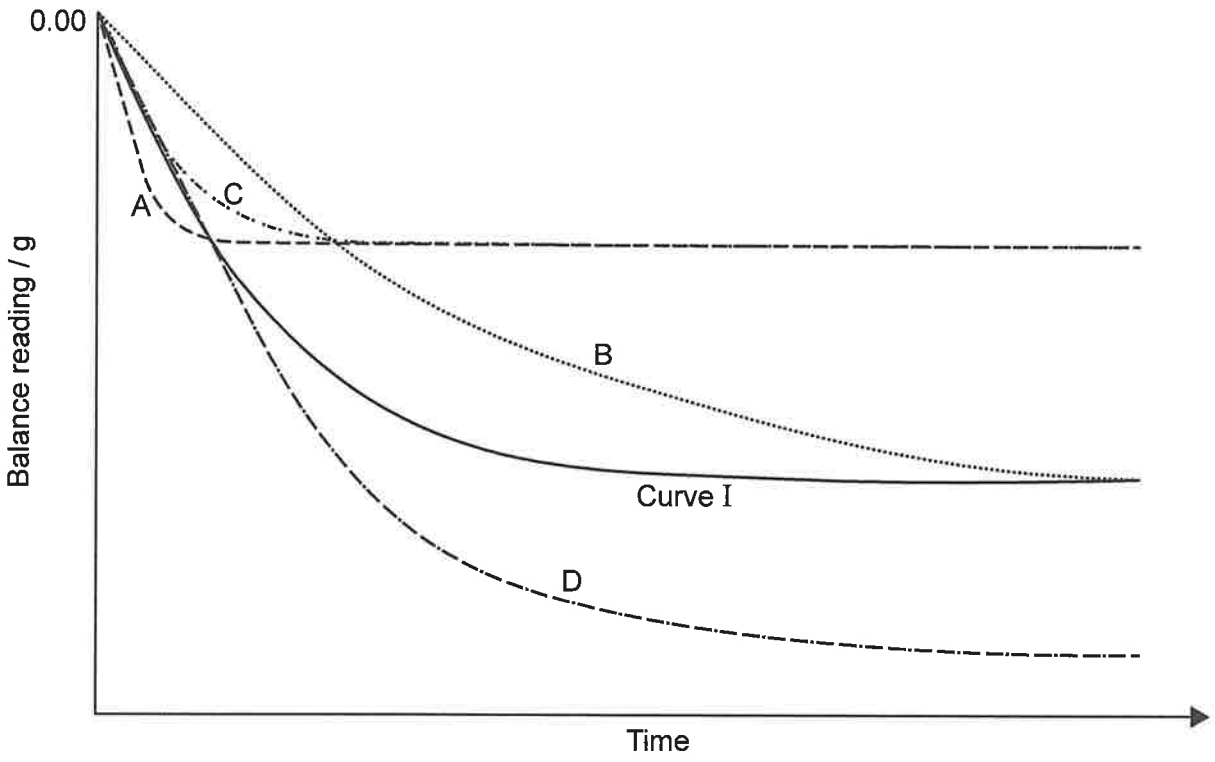
D. The activation energy of the reaction is low.

17. The mass of a flask containing excess calcium carbonate, $CaCO_3(s)$, reacting with 100 cm^3 of 0.50 mol dm^{-3} hydrochloric acid, HCl (aq), was monitored with time at 25 °C.



Curve I was obtained under these conditions.

Which curve corresponds to the experiment when it was repeated at the same temperature using the same mass of same sized pieces of calcium carbonate and 50 cm^3 of 0.50 mol dm^{-3} hydrochloric acid?



18. Which pair of changes will both shift the position of equilibrium to the left?

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -92\,kJ$$

	Temperature	Pressure
A.	increase	increase
B.	decrease	decrease
C.	increase	decrease
D.	decrease	increase

19. Consider the equilibrium between dinitrogen tetraoxide, $N_2O_4(g)$, and nitrogen dioxide, $NO_2(g)$.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

At a certain temperature, the K_c value for this reaction is 5. What is the K_c value for the reaction below at the same temperature?

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

A. 5

B. $\frac{1}{5}$

C. $\sqrt{5}$

D. 5^2

20. What is the conjugate base of OH^-?

A. O^{2-}

B. H_2O

C. H_3O^+

D. H^-

21. What is the pH of a $0.010\,mol\,dm^{-3}$ aqueous solution of HCl?

A. 1.0×10^{-2}

B. 1.0×10^{-1}

C. 1.00

D. 2.00

22. Which statement is correct for the following spontaneous reaction?

$$C_2O_4^{2-}(aq) + S_2O_8^{2-}(aq) \rightarrow 2SO_4^{2-}(aq) + 2CO_2(g)$$

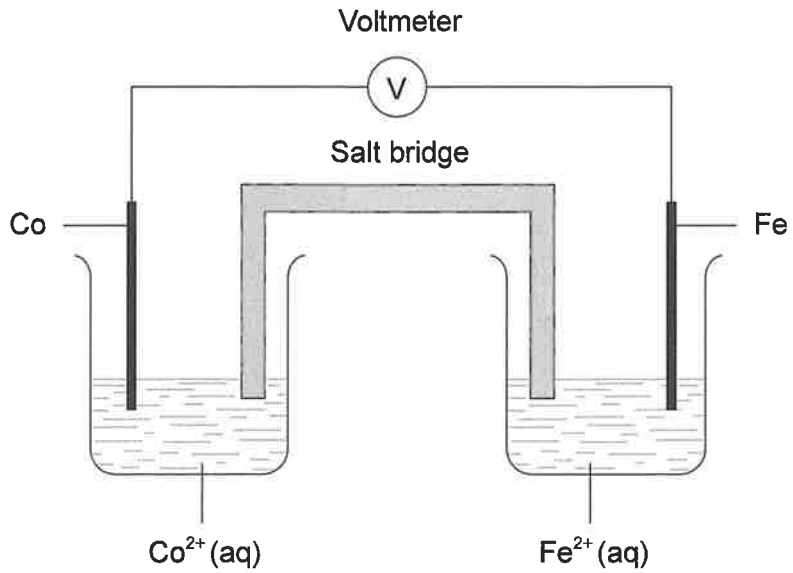
A. $C_2O_4^{2-}$ is the oxidizing agent and $S_2O_8^{2-}$ is oxidized.

B. $S_2O_8^{2-}$ is the oxidizing agent and $C_2O_4^{2-}$ is oxidized.

C. $C_2O_4^{2-}$ is the oxidizing agent and $S_2O_8^{2-}$ is reduced.

D. $S_2O_8^{2-}$ is the oxidizing agent and $C_2O_4^{2-}$ is reduced.

23. Iron is a more reactive metal than cobalt. Which statement is correct about the voltaic cell below?



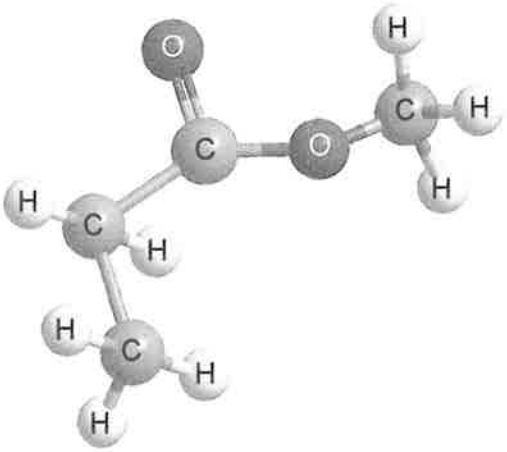
A. Electrons flow from cobalt to iron in the wire.

B. Negative ions flow through the salt bridge to the iron half-cell.

C. The mass of the cobalt electrode decreases.

D. Reduction occurs at the iron electrode.

24. What is the IUPAC name of this compound?



A. Methyl ethanoate

B. Ethyl methanoate

C. Methyl propanoate

D. Propyl methanoate

25. What is the major product formed when Cl_2 is added to propene?

A. 2,2-dichloropropane

B. 1,2-dichloropropane

C. 1-chloroprop-2-ene

D. 2-chloropropane

26. Which of the three statements are correct for propanone and butanone that belong to the same homologous series?

I. They have the same empirical formula.

II. They differ in a CH_2.

III. They both have the general formula $C_nH_{2n}O$.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

27. Which of the following pairs are structural isomers?

I. $CH_3CHCHCH_2Br$ and $CH_3CHBrCH_2CH_3$

II. $(CH_3)_2CHCH_2CH_3$ and $CH_3CH_2CH_2CH_2CH_3$

III. CH_3OCH_3 and CH_3CH_2OH

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

28. What is the simplest ratio of the area under the signals in the ^1H NMR spectrum of pentan-3-one?

A. 3:3:2:2

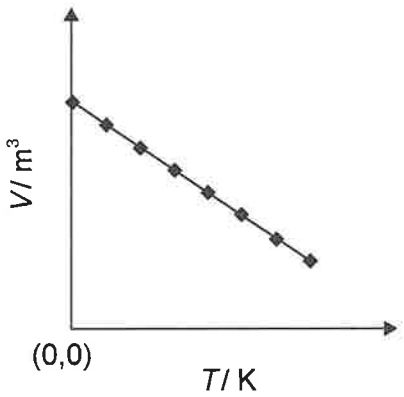
B. 1:1

C. 6:4

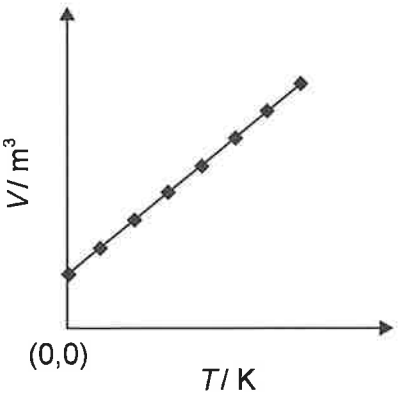
D. 3:2

29. Which graph shows the correct relationship between the volume and temperature of an ideal gas at constant pressure?

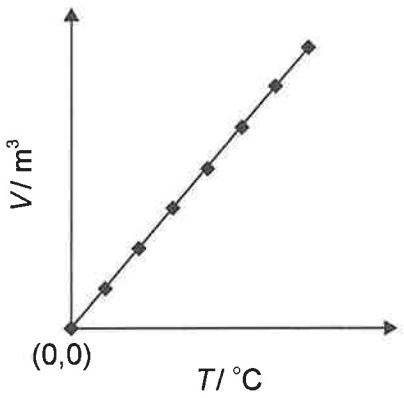
A.



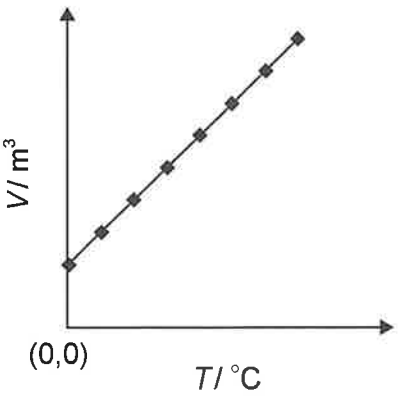
B.



C.



D.



30. The following measurements were made during an experiment.

Initial temperature = $17 \pm 1\ ^\circ C$
Final temperature = $43 \pm 1\ ^\circ C$

What is the uncertainty associated with the temperature rise?

A. $1 + 1$

B. $1 - 1$

C. $\frac{1}{17} + \frac{1}{43}$

D. $\left(\frac{1}{17} + \frac{1}{43}\right) \times 26$