Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

4 November 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]**.

8824 – 9543

14 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)

8824–9543

1. How many moles of phosphate ions, PO_4^{3-}, are there in 103.39 g of $Ca_3(PO_4)_2$?
$M_r = 310.18$

A. 0.11

B. 0.33

C. 0.67

D. 2.00

2. What is the sum of the coefficients for the balanced equation of the combustion of iron(II) sulphide using the smallest whole numbers?

$$\_FeS(s) + \_O_2(g) \rightarrow \_Fe_2O_3(s) + \_SO_2(g)$$

A. 6

B. 7

C. 14

D. 17

3. What is the yield of sodium chloride, in grams, when 2.30 g of sodium reacts with 11.4 dm^3 of chlorine gas at STP?
M_r NaCl = 58.4
Molar volume of gas = 22.7 $dm^3\,mol^{-1}$

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

A. 2.92

B. 5.84

C. 29.2

D. 58.4

4. What is the pressure, in Pa, inside a 3.0 dm^3 cylinder containing 64 g of O_2 at 25.0 ºC?
R = 8.31 $JK^{-1}mol^{-1}$; $PV = nRT$

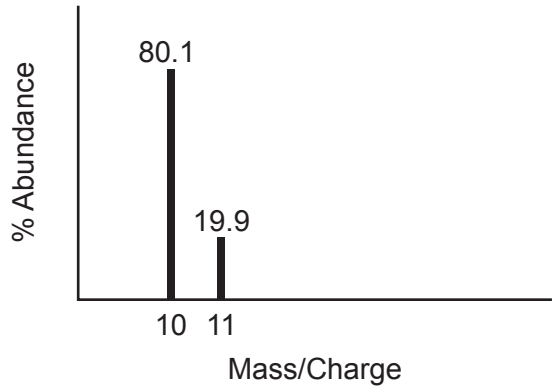
A. $\frac{2 \times 8.31 \times 25}{3.0}$

B. $\frac{2 \times 8.31 \times 298}{3.0 \times 10^{-3}}$

C. $\frac{2 \times 8.31 \times 298}{3.0}$

D. $\frac{4 \times 8.31 \times 298}{3.0 \times 10^{-3}}$

5. What is the A_r of the element as determined from its mass spectrum below?



A. 10.0

B. 10.2

C. 10.5

D. 10.8

6. What is correct for the wavelength and energy of the radiation of the ultraviolet and visible regions of the electromagnetic spectrum?

	Ultraviolet region	Visible region
A.	Lower wavelength and higher energy	Higher wavelength and lower energy
B.	Lower wavelength and lower energy	Higher wavelength and higher energy
C.	Higher wavelength and lower energy	Lower wavelength and higher energy
D.	Higher wavelength and higher energy	Lower wavelength and lower energy

7. Which statements are correct regarding the organization of elements in the periodic table?

I. Elements with atomic numbers 4, 12 and 20 have atoms with the same number of energy levels occupied with electrons.

II. Elements with atomic numbers 9, 17 and 35 have atoms with the same number of electrons in the outer shell.

III. The periodic table is divided into blocks based on the sub-levels occupied by electrons.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which of these period 3 oxides forms a solution with pH<7 when added to water?

A. Al_2O_3

B. MgO

C. Na_2O

D. P_4O_6

9. What type of bond forms between N and H when ammonia reacts with water?

$$NH_3(g) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$$

A. Ionic

B. Dipole-dipole

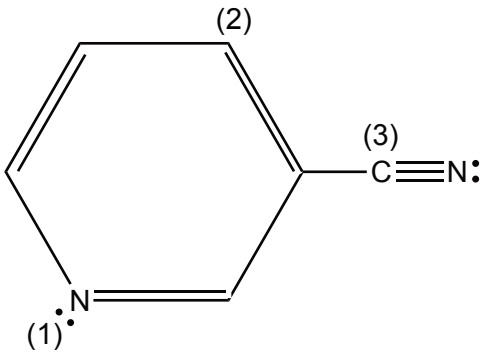
C. Coordinate covalent

D. Metallic bond

10. Which types of intermolecular force exist between CH_4, CH_3OH and CH_3Cl molecules?

	CH_4	CH_3OH	CH_3Cl
A.	London dispersion only	London dispersion, H-bonding, dipole-dipole	London dispersion, dipole-dipole
B.	London dispersion, H-bonding	London dispersion, H-bonding, dipole-dipole	London dispersion, H-bonding, dipole-dipole
C.	London dispersion only	London dispersion, dipole-dipole	London dispersion only
D.	London dispersion, H-bonding	London dispersion only	London dispersion, dipole-dipole

11. What is the molecular geometry of the numbered atoms in the molecule shown below?



	N(1)	C(2)	C(3)
A.	Bent	Trigonal planar	Linear
B.	Trigonal planar	Bent	Bent
C.	Tetrahedral	Trigonal planar	Bent
D.	Bent	Tetrahedral	Linear

12. Which statements are correct for alloys?

I. They are homogeneous mixtures of metals with other metals or non-metals.

II. The different sizes of atoms in alloys prevent layers of metallic cations sliding over each other easily.

III. Adding carbon to iron produces an alloy that is stronger than pure iron.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. Which of the following reactions represents enthalpy of formation, $\Delta H_f^{\ominus}$?

A. $C_2H_4(g) + HBr(g) \rightarrow C_2H_5Br(g)$

B. $Al(s) + \frac{3}{2}H_2(g) + \frac{3}{2}O_2(g) \rightarrow Al(OH)_3(s)$

C. $CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$

D. $H(g) + N(g) + O_3(g) \rightarrow HNO_3(l)$

14. Consider the following equations:

$$H_2(g) + F_2(g) \rightarrow 2HF(g) \qquad \Delta H^{\ominus} = -x\,kJ$$

$$C(s) + 2F_2(g) \rightarrow CF_4(g) \qquad \Delta H^{\ominus} = -y\,kJ$$

$$2C(s) + 2H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^{\ominus} = +z\,kJ$$

What is the $\Delta H^{\ominus}$ of the reaction?

$$C_2H_4(g) + 6F_2(g) \rightarrow 2CF_4(g) + 4HF(g)$$

A. $-x - y - z$

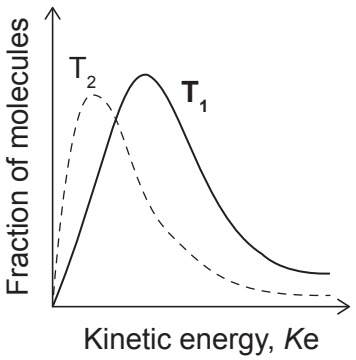
B. $-x - y + z$

C. $-2x + 2y - z$

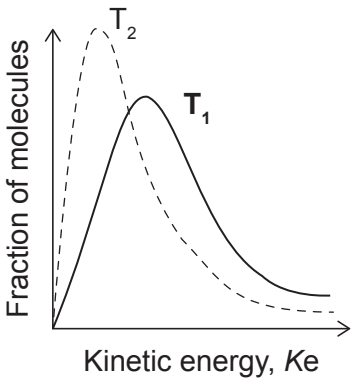
D. $-2x - 2y - z$

15. Which of the diagrams represents the Maxwell–Boltzmann distribution of kinetic energy of molecules of the same sample of a gas at two temperatures, T1 and T2, when T1>T2?

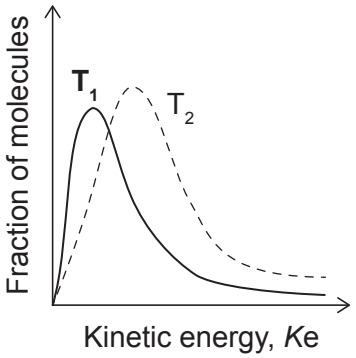
A.



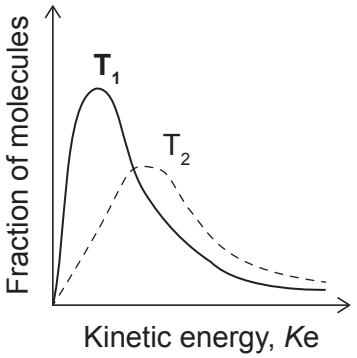
B.



C.



D.



16. What is the enthalpy change, in $kJ\,mol^{-1}$, when 107 g of solid ammonium chloride, NH_4Cl, are added to water to form 50.0 cm^3 of solution, producing a maximum decrease of 28 °C?
M_r $NH_4Cl = 53.5$
Specific heat capacity of water= $4.18\,J\,g^{-1}\,K^{-1}$

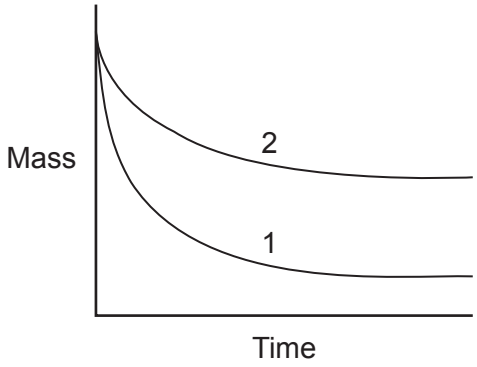
A. $\Delta H = \dfrac{-50.0 \times 4.18 \times (28 + 273)}{2 \times 1000}$

B. $\Delta H = \dfrac{-50.0 \times 4.18 \times 28}{2 \times 1000}$

C. $\Delta H = \dfrac{50.0 \times 4.18 \times (28 + 273)}{2 \times 1000}$

D. $\Delta H = \dfrac{50.0 \times 4.18 \times 28}{2 \times 1000}$

17. Excess magnesium powder was added to a beaker of hydrochloric acid, HCl (aq). The mass of the beaker and its contents was recorded and plotted against time to give line 1.



Which change could give line 2?

A. Using the same volume of more dilute HCl (aq)

B. Using the same mass of Mg ribbon

C. Increasing the temperature

D. Doubling the mass of powdered Mg

18. Carbon dioxide dissolves in water as shown in the equation below. What will happen if the temperature of the aqueous solution is increased?

$$CO_2(g) + 2H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq) \qquad \Delta H^{\ominus} = -19.3\,kJ\,mol^{-1}$$

A. The equilibrium shifts to the right and pH decreases.

B. The equilibrium shifts to the right and pH increases.

C. The equilibrium shifts to the left and pH increases.

D. The equilibrium shifts to the left and pH decreases.

19. The pH of an aqueous solution **Z** is 5 and the pH of an aqueous solution **X** is 10. What is the ratio of their H_3O^+ concentrations?

A. $[H_3O^+]$ is 2 times lower in **X** than in **Z**.

B. $[H_3O^+]$ is 5 times lower in **X** than in **Z**.

C. $[H_3O^+]$ is 1×10^2 times lower in **X** than in **Z**.

D. $[H_3O^+]$ is 1×10^5 times lower in **X** than in **Z**.

20. Which of these has the weakest conjugate base?

A. HCl

B. $NaOH$

C. CH_3CH_2COOH

D. $NaCl$

21. In which reaction does H_2 act as an oxidizing agent?

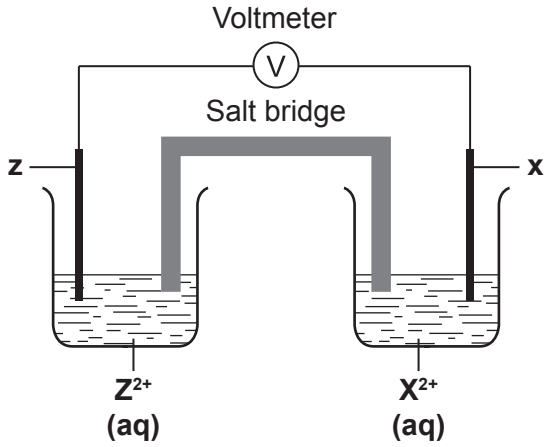
A. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

B. $2Na(s) + H_2(g) \rightarrow 2NaH(s)$

C. $Cl_2(g) + H_2(g) \rightarrow 2HCl(g)$

D. $H_2CCH_2(g) + H_2(g) \rightarrow H_3CCH_3(g)$

22. A voltaic cell is constructed from half-cells containing metals **X** and **Z** as electrodes. **Z** is the more reactive metal. What will occur when this cell produces electricity?



A. Positive ions flow through the salt bridge to **Z** half-cell.

B. Electrons flow from **X** half-cell to **Z** half-cell.

C. The concentration of $\mathbf{X}^{2+}$ increases.

D. Mass of electrode **Z** decreases.

23. What happens when chlorine gas, $Cl_2(g)$, is bubbled through an aqueous solution of sodium iodide, NaI?

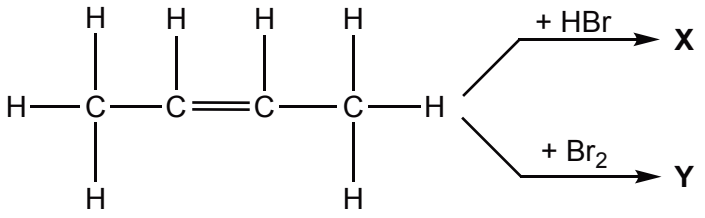
A. Chlorine is oxidized to chlorate(V) ions.

B. Chlorine is oxidized to chloride.

C. Iodide ions are oxidized to iodine.

D. There is no reaction.

24. Which products are formed when but-2-ene reacts separately with aqueous hydrogen bromide, HBr, and with bromine water, $Br_2(aq)$?



	X	Y
A.	$CH_3CH_2CHBrCH_3$	$CH_3CHBrCHBrCH_3$
B.	$BrCH_2CH_2CH_2CH_3$	$Br_2CHCHCHCH_3 + H_2$
C.	$BrCH_2CHCHCH_3 + H_2$	$CH_3CHBrCHBrCH_3$
D.	$CH_3CH_2CHBrCH_3$	$CH_3CHCBrCH_3 + HBr$

25. Which of the following compounds can react with acidified potassium dichromate to give an acid?

A. $CH_3CH(OH)CH_3$

B. CH_3COCH_3

C. $CH_3CH_2CH(CH_2OH)CH_2CH_3$

D. $CH_3C(CH_3)(OH)CH_3$

26. How many structural isomers of the alcohol with molecular formula C_4H_9OH exist?

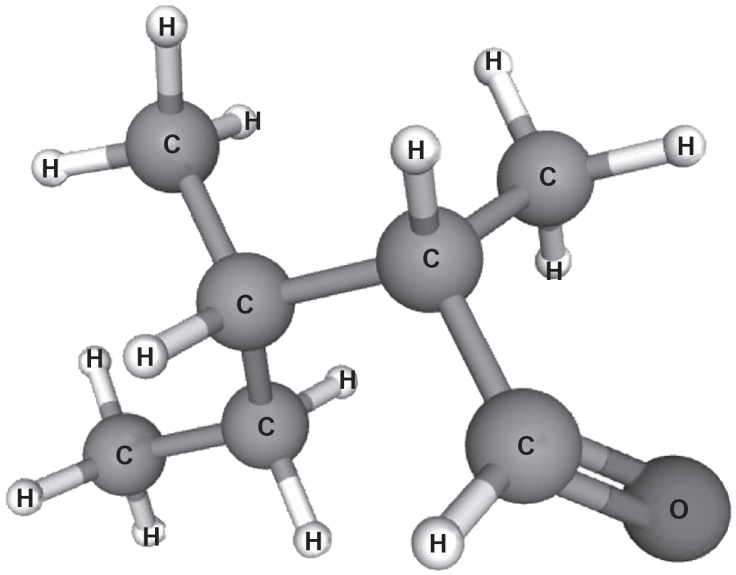
A. 2

B. 3

C. 4

D. 5

27. What is the IUPAC name of this compound?



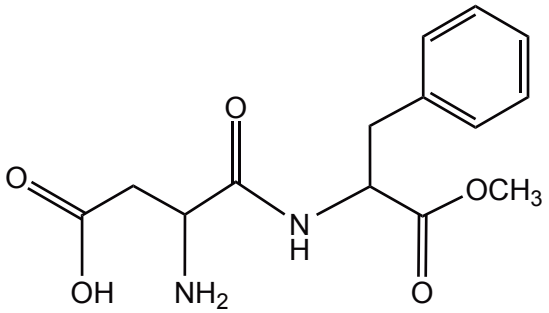
A. 2,3-dimethylpentanal

B. 2,3-methylpentanal

C. 2-methyl-3-ethylbutanal

D. 3-ethyl-2-methylbutanal

28. Which of these functional groups are present in aspartame?



A. Carboxyl, secondary amino and ether

B. Carboxyl, secondary amino and ester

C. Ether, primary amino and secondary amino

D. Ester, primary amino and carboxyl

29. Which statements are correct about the molecular ion, M^+, in a mass spectrum?

I. The M^+ is **not** always the peak with highest intensity in the mass spectrum.

II. The M^+ is always the most stable fragment formed during electron bombardment.

III. The *m/z* ratio of the M^+ ion peak gives the relative molecular mass of the molecule.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

30. A student performs an investigation to determine the content of ethanoic acid in vinegar samples using a non-standardized sodium hydroxide solution. Which type of error will occur and how will this affect the quality of the data obtained?

A. Systematic error and lower accuracy

B. Systematic error and lower precision

C. Random error and lower precision

D. Random error and lower accuracy

References: