Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 18 May 2022 (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]**.

2222 – 6116

12 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			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											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)

2222–6116

1. What is the concentration of chloride ions, in mol dm^{-3}, in a solution formed by mixing 200 cm^3 of 1 mol dm^{-3} HCl with 200 cm^3 of 5 mol dm^{-3} NaCl?

A. 1

B. 2

C. 3

D. 6

2. 30 g of an organic compound produces 44 g CO_2 and 18 g H_2O as the only combustion products. Which of the following is the empirical formula for this compound?

$$M_r\ CO_2 = 44\ M_r\ H_2O = 18$$

A. CH_2

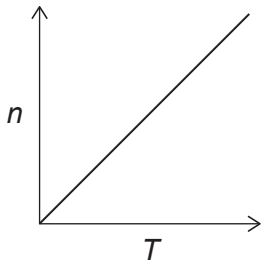
B. CH_3

C. CHO

D. CH_2O

3. Which graph represents the relationship between the amount of gas, n, and the absolute temperature, T, with all other variables in the ideal gas equation, $PV = nRT$, held constant?

A.



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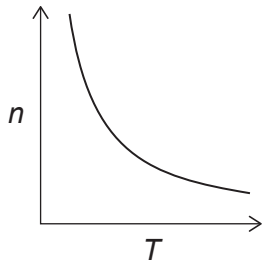

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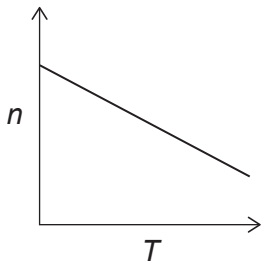

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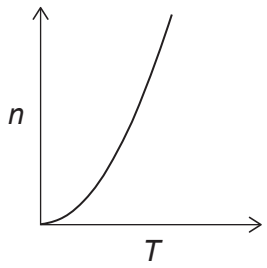


4. Which equation represents the deposition of iodine?

A. $I_2(g) \rightarrow I_2(l)$

B. $I_2(g) \rightarrow I_2(s)$

C. $I_2(l) \rightarrow I_2(g)$

D. $I_2(s) \rightarrow I_2(g)$

5. Which experimental results support the theory that electrons exist in discrete energy levels?

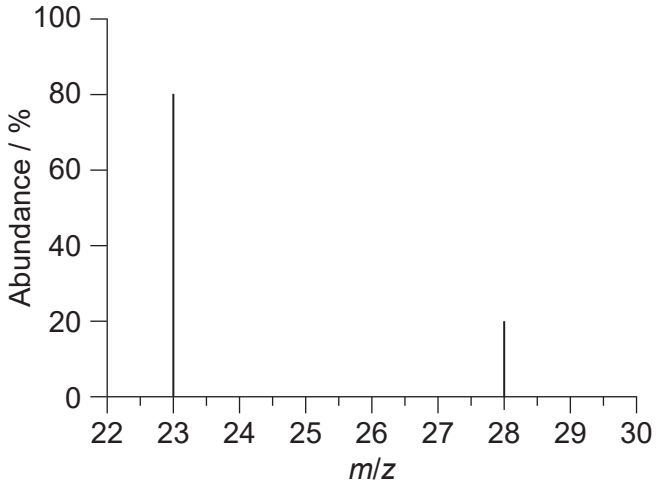
A. ^{1}H NMR

B. X-ray diffraction pattern

C. Emission spectra

D. IR spectra

6. What is the relative atomic mass of an element with the following mass spectrum?



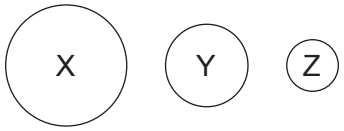
A. 23

B. 24

C. 25

D. 28

7. Three elements, X, Y, and Z are in the same period of the periodic table. The relative sizes of their atoms are represented by the diagram.



Which general trends are correct?

	Ionization energy	Effective nuclear charge	Least to most acidic oxide
A.	X < Y < Z	X < Y < Z	Z < Y < X
B.	X < Y < Z	Z < Y < X	X < Y < Z
C.	X < Y < Z	X < Y < Z	X < Y < Z
D.	Z < Y < X	Z < Y < X	Z < Y < X

8. Which element is found in the 4th group, 6th period of the periodic table?

A. Selenium

B. Lead

C. Chromium

D. Hafnium

9. Which statement best describes the **intramolecular** bonding in HCN(l)?

A. Electrostatic attractions between H^+ and CN^- ions

B. Hydrogen bonding

C. Van der Waals forces and hydrogen bonding

D. Electrostatic attractions between pairs of electrons and positively charged nuclei

10. What is the type of bonding in a compound that has high boiling and melting points, poor electrical conductivity, and low solubility in water?

A. Ionic

B. Molecular covalent

C. Metallic

D. Giant covalent

11. What is the name of the compound with formula $Ti_3(PO_4)_2$?

A. Titanium phosphate

B. Titanium(II) phosphate

C. Titanium(III) phosphate

D. Titanium(IV) phosphate

12. What is the main interaction between liquid CH_4 molecules?

A. London (dispersion) forces

B. Dipole–dipole forces

C. Hydrogen bonding

D. Covalent bonding

13. What is correct about energy changes during bond breaking and bond formation?

	Bond breaking	**Bond formation**
A.	exothermic and ΔH positive	endothermic and ΔH negative
B.	exothermic and ΔH negative	endothermic and ΔH positive
C.	endothermic and ΔH positive	exothermic and ΔH negative
D.	endothermic and ΔH negative	exothermic and ΔH positive

14. Which combination of ΔH_1, ΔH_2, and ΔH_3 would give the enthalpy of the reaction?

$$CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

$$\Delta H_1 \quad C(s) + O_2(g) \rightarrow CO_2(g)$$

$$\Delta H_2 \quad S(s) + O_2(g) \rightarrow SO_2(g)$$

$$\Delta H_3 \quad C(s) + 2S(s) \rightarrow CS_2(l)$$

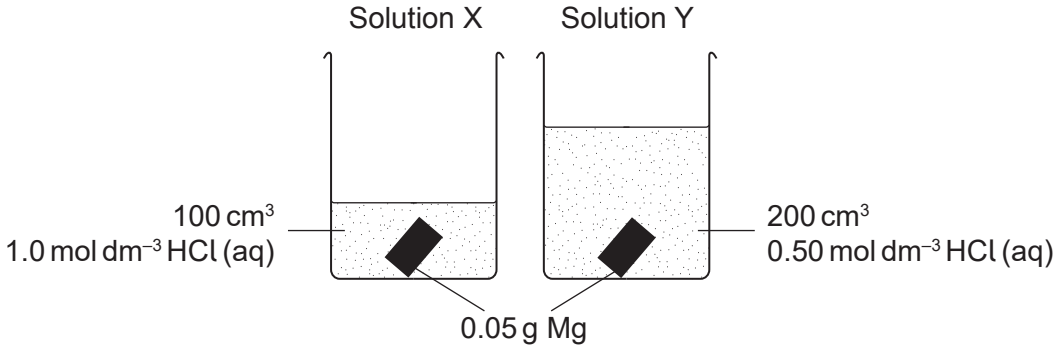
A. $\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$

B. $\Delta H = \Delta H_1 + \Delta H_2 - \Delta H_3$

C. $\Delta H = \Delta H_1 + 2(\Delta H_2) + \Delta H_3$

D. $\Delta H = \Delta H_1 + 2(\Delta H_2) - \Delta H_3$

15. Which statement is correct about identical pieces of magnesium added to two solutions, X and Y, containing hydrochloric acid at the same temperature?



A. Solution X will reach a higher maximum temperature.

B. Solution Y will reach a higher maximum temperature.

C. Solutions X and Y will have the same temperature rise.

D. It is not possible to predict whether X or Y will have the higher maximum temperature because we cannot identify the limiting reactant.

16. Why does a reaction for a sample of gases, at constant temperature, occur faster at higher pressure?

A. Collisions are more frequent.

B. Collisions are more energetic.

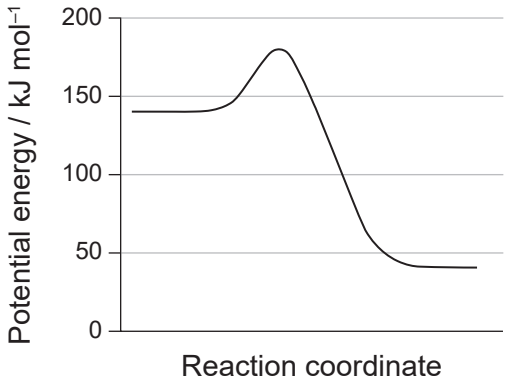
C. High pressure lowers activation energy.

D. The reaction is more exothermic at high pressure.

17. A reaction has an activation energy of $40\,kJ\,mol^{-1}$ and an enthalpy change of $-60\,kJ\,mol^{-1}$.

Which potential energy diagram illustrates this reaction?

A.



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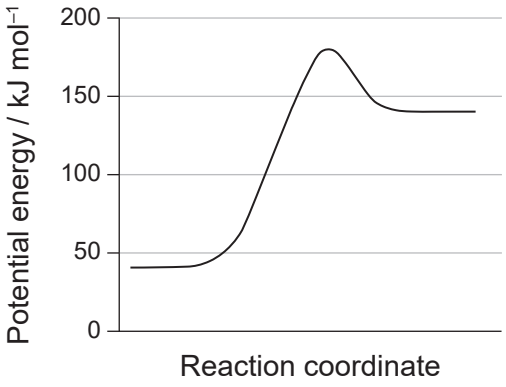
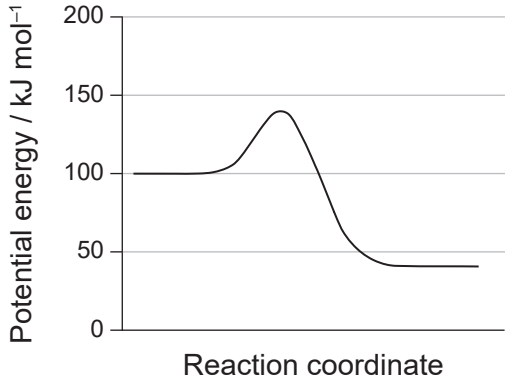
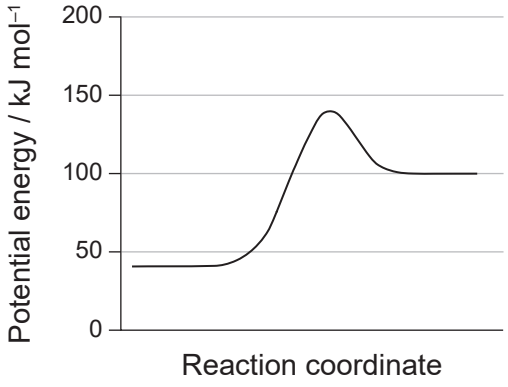


C.



D.



18. The equilibrium constant, K_c, for the reaction $2A + 4B \rightleftharpoons 2C + 4D$ has a value of 4.0.
What is the value of K_c for the reaction below at the same temperature?

$$C + 2D \rightleftharpoons A + 2B$$

A. 0.25

B. 0.50

C. 1.0

D. 16

19. Which of the $0.001\,mol\,dm^{-3}$ solutions is most likely to have a pH of 11.3?

A. $Ca(OH)_2(aq)$

B. $H_3PO_4(aq)$

C. $NaOH(aq)$

D. $NH_4OH(aq)$

20. What is the strongest acid in the equation below?

$$H_3AsO_4 + H_2O \rightleftharpoons H_2AsO_4^- + H_3O^+ \qquad K_c = 4.5 \times 10^{-4}$$

A. H_3AsO_4

B. H_2O

C. $H_2AsO_4^-$

D. H_3O^+

21. Which species could be reduced to form NO_2?

A. N_2

B. NO_3^-

C. HNO_2

D. NO

22. Which combination best describes what is happening to chloromethane, CH_3Cl, in the equation below?

$$CH_3Cl\,(g) + H_2\,(g) \rightleftharpoons CH_4\,(g) + HCl\,(g)$$

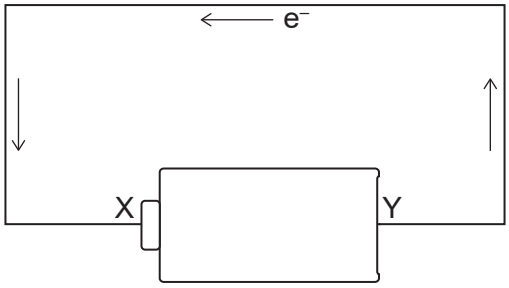
A. Oxidation and addition

B. Oxidation and substitution

C. Reduction and addition

D. Reduction and substitution

23. The arrows represent electron flow in the diagram. What does terminal X on the battery represent?



A. Anode and positive terminal

B. Anode and negative terminal

C. Cathode and positive terminal

D. Cathode and negative terminal

24. How many dichlorinated butane isomers can be formed by the halogenation of $CH_3CH_2CH_2CH_3$ with excess Cl_2 in the presence of UV light?

A. 4

B. 6

C. 8

D. 10

25. Which structure represents a repeating unit of a polymer formed from propene?

A. $–CH_2–CH(CH_3)–$

B. $–CH_2–CH_2–CH_2–$

C. $–CH(CH_3)–CH(CH_3)–$

D. $–CH_2–CH_2–$

26. Which is a homologous series?

A. C_2H_4, C_3H_5, C_4H_6

B. C_2H_2, C_3H_4, C_4H_6

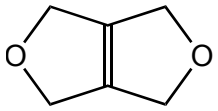
C. C_2H_2, C_2H_4, C_2H_6

D. C_2H_2, C_4H_4, C_6H_6

27. Which reaction mechanisms are typical for alcohols and halogenoalkanes?

	Alcohols	Halogenoalkanes
A.	Electrophilic addition	Electrophilic addition
B.	Electrophilic addition	Nucleophilic substitution
C.	Nucleophilic substitution	Electrophilic addition
D.	Nucleophilic substitution	Nucleophilic substitution

28. How many signals are observed in the ^{1}H NMR spectrum of this compound?



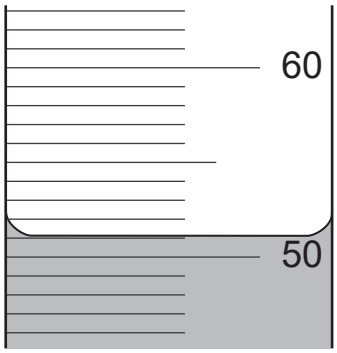
A. 1

B. 2

C. 3

D. 4

29. What is the uncertainty, in cm^3, of this measurement?



A. ±0.01

B. ±0.1

C. ±0.15

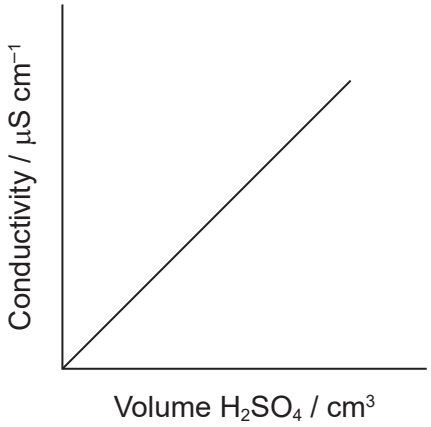
D. ±1

30. 20 cm^3 of 1 mol dm^{-3} sulfuric acid was added dropwise to 20 cm^3 of 1 mol dm^{-3} barium hydroxide producing a precipitate of barium sulfate.

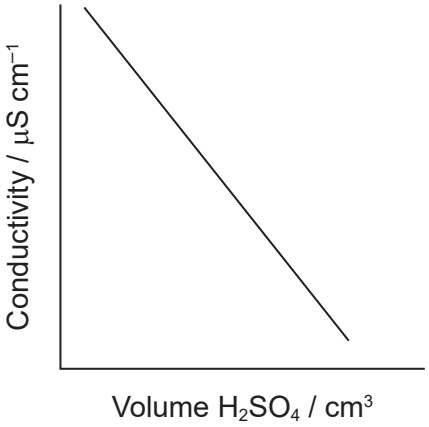
$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(l) + BaSO_4(s)$$

Which graph represents a plot of conductivity against volume of acid added?

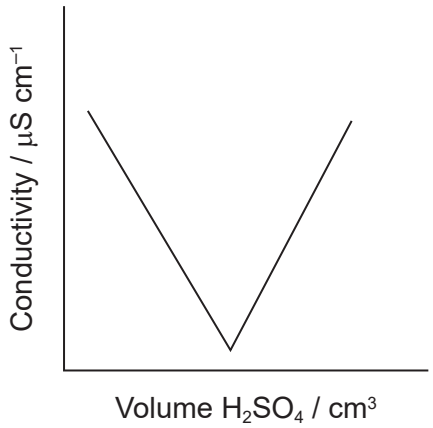
A.



B.



C.



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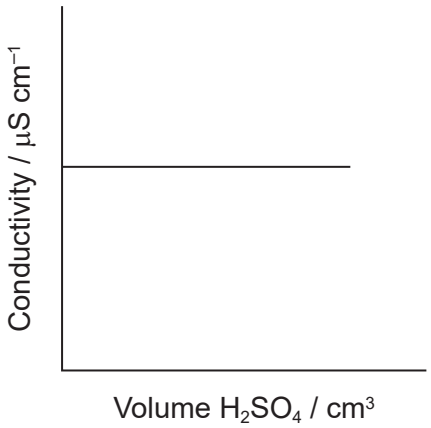

References: