Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 22 May 2019 (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]**.

2219 – 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)

1. How many moles of magnesium hydroxide are produced with 0.50 mol of ammonia?

$$Mg_3N_2(s) + 6H_2O(l) \rightarrow 3Mg(OH)_2(aq) + 2NH_3(aq)$$

A. 0.25

B. 0.33

C. 0.75

D. 1.5

2. What is the sum of the integer coefficients when propene undergoes complete combustion?

$$\_\_C_3H_6(g) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(l)$$

A. 11

B. 17

C. 21

D. 23

3. What is the volume of gas when the pressure on 100 cm^3 of gas is changed from 400 kPa to 200 kPa at constant temperature?

A. 50.0 cm^3

B. 100 cm^3

C. 200 cm^3

D. 800 cm^3

4. What is the concentration, in mol dm^{-3}, of 20.0 g of NaOH ($M_r = 40.0$) in 500.0 cm^3?

A. 0.250

B. 0.500

C. 1.00

D. 4.00

5. Which is correct for $^{34}_{16}S^{2-}$?

	Protons	Neutrons	Electrons
A.	16	18	14
B.	18	16	18
C.	16	18	16
D.	16	18	18

6. Which transition in the hydrogen atom emits visible light?

A. $n = 1$ to $n = 2$

B. $n = 2$ to $n = 3$

C. $n = 2$ to $n = 1$

D. $n = 3$ to $n = 2$

7. Which of the following would have the same numerical value for all elements in the same period?

A. Highest energy levels occupied

B. Energy sub-levels occupied

C. Orbitals occupied

D. Valence electrons

8. How do the following properties change down Group 17 of the periodic table?

	Ionization energy	Ionic radius
A.	increases	decreases
B.	increases	increases
C.	decreases	increases
D.	decreases	decreases

9. How does a lithium atom form the most stable ion?

A. The atom gains a proton to form a positive ion.

B. The atom loses a proton to form a negative ion.

C. The atom loses an electron to form a positive ion.

D. The atom gains an electron to form a negative ion.

10. Which combination causes the strength of metallic bonding to increase?

	Charge on cations	Ionic radius
A.	smaller	smaller
B.	larger	larger
C.	smaller	larger
D.	larger	smaller

11. Which molecule contains an incomplete octet of electrons?

A. NF_3

B. BF_3

C. BrF

D. SF_2

12. Which compound has hydrogen bonds between its molecules?

A. CH_4

B. CH_4O

C. CH_3Cl

D. CH_2O

13. Consider the following equations.

$$2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s) \qquad \Delta H^{\ominus} = -1670\,kJ$$

$$Mn(s) + O_2(g) \rightarrow MnO_2(s) \qquad \Delta H^{\ominus} = -520\,kJ$$

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

$$4Al(s) + 3MnO_2(s) \rightarrow 2Al_2O_3(s) + 3Mn(s)$$

A. $-1670 + 520$

B. $\frac{3}{2}(-1670) + 3(520)$

C. $2(-1670) + 3(-520)$

D. $2(-1670) + 3(520)$

14. Methane undergoes incomplete combustion.

$$2CH_4(g) + 3O_2(g) \rightarrow 2CO(g) + 4H_2O(g)$$

What is the enthalpy change, in kJ, using the bond enthalpy data given below?

Bond	**Average bond enthalpy / kJ mol^{-1}**
C–H	414
O–H	463
O=O	498
C≡O	1077

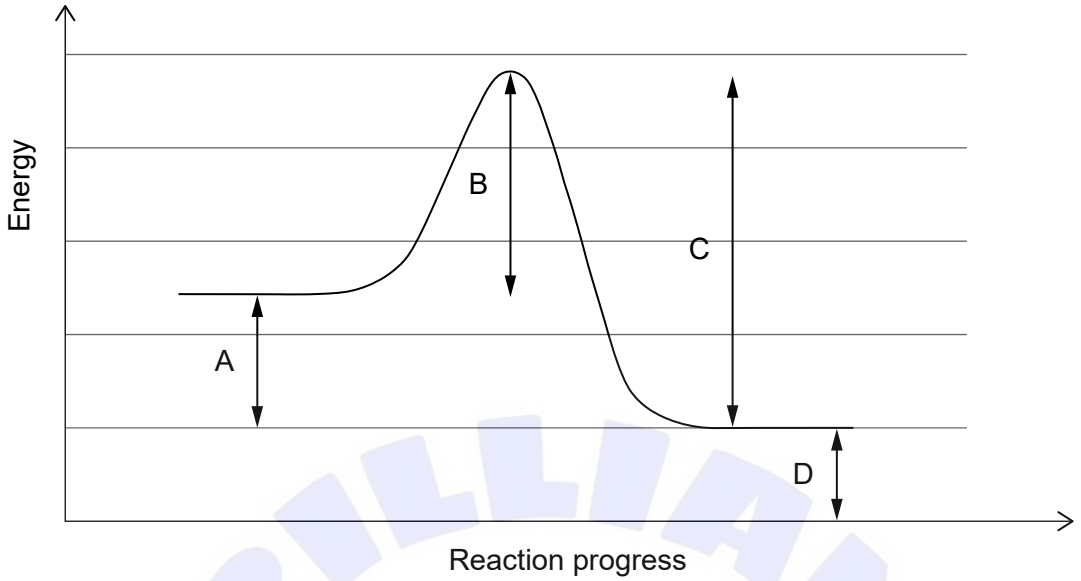
A. $[2(1077) + 4(463)] - [2(414) + 3(498)]$

B. $[2(414) + 3(498)] - [2(1077) + 4(463)]$

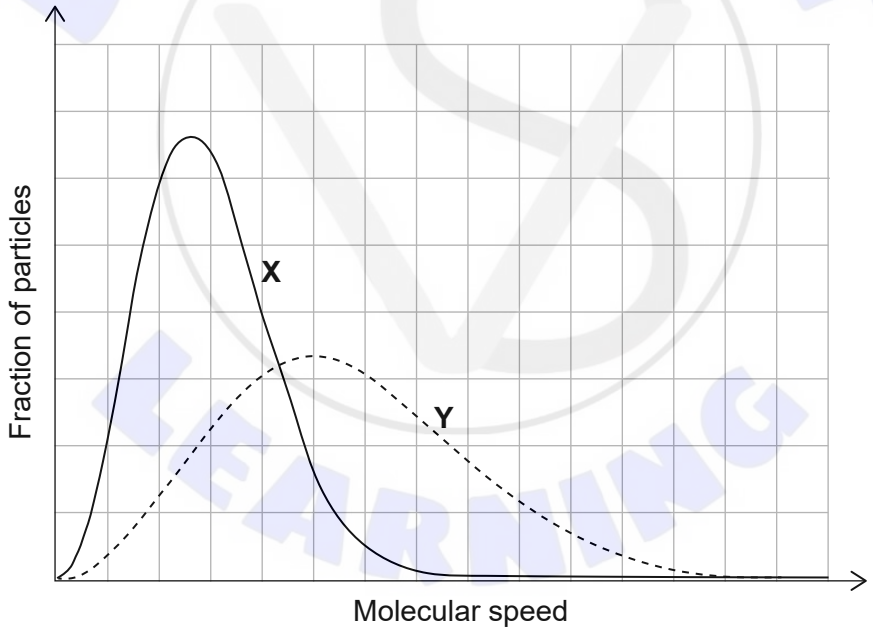
C. $[8(414) + 3(498)] - [2(1077) + 8(463)]$

D. $[2(1077) + 8(463)] - [8(414) + 3(498)]$

15. Which is the activation energy of the forward reaction?



16. The same amount of two gases, **X** and **Y**, are in two identical containers at the same temperature. What is the difference between the gases?



A. **X** has the higher molar mass.

B. **Y** has the higher molar mass.

C. **X** has the higher average kinetic energy.

D. **Y** has the higher average kinetic energy.

17. Several reactions of calcium carbonate with dilute hydrochloric acid are carried out at the same temperature.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which reaction has the greatest rate?

	Concentration of HCl (aq)	**Surface area of same mass of $CaCO_3$ (s)**
A.	higher	larger
B.	lower	smaller
C.	lower	larger
D.	higher	smaller

18. What is the equilibrium constant expression for the following equation?

$$2NO_2(g) + F_2(g) \rightleftharpoons 2NO_2F(g)$$

A. $\frac{2[NO_2F]}{2[NO_2] + [F_2]}$

B. $\frac{2[NO_2F]}{2[NO_2][F_2]}$

C. $\frac{[NO_2]^2[F_2]}{[NO_2F]^2}$

D. $\frac{[NO_2F]^2}{[NO_2]^2[F_2]}$

19. What is the pH of $0.001\,mol\,dm^{-3}$ NaOH (aq)?

A. 1

B. 3

C. 11

D. 13

20. What is the major reason why the pH of unpolluted rain is less than 7?

A. methane

B. carbon dioxide

C. nitrogen oxides

D. sulfur dioxide

21. Which species contains nitrogen with the highest oxidation state?

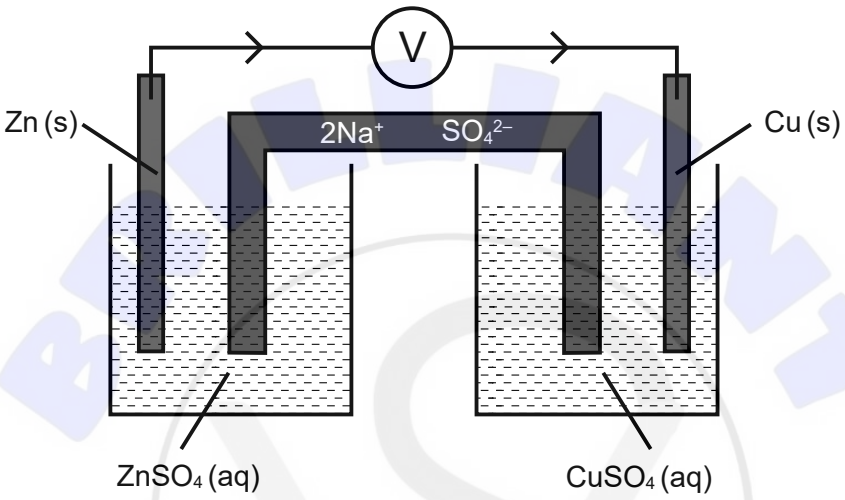
A. NO_3^-

B. NO_2^-

C. NO_2

D. N_2O

22. Consider the following electrochemical cell.



What happens to the ions in the salt bridge when a current flows?

A. Na^+ ions flow to the zinc half-cell and SO_4^{2-} ions flow to the copper half-cell.

B. Na^+ ions flow to the copper half-cell and SO_4^{2-} ions flow to the zinc half-cell.

C. Na^+ and SO_4^{2-} ions flow to the copper half-cell.

D. Na^+ and SO_4^{2-} ions flow to the zinc half-cell.

23. The following reaction occurs in a voltaic (galvanic) cell.

$$Mg(s) + 2Ag^+(aq) \rightarrow Mg^{2+}(aq) + 2Ag(s)$$

Which reaction takes place at each electrode?

	Anode (negative electrode)	**Cathode (positive electrode)**
A.	$Ag(s) \rightarrow Ag^+(aq) + e^-$	$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$
B.	$Ag^+(aq) + e^- \rightarrow Ag(s)$	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$
C.	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$	$Ag^+(aq) + e^- \rightarrow Ag(s)$
D.	$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	$Ag(s) \rightarrow Ag^+(aq) + e^-$

24. Which compound has the lowest boiling point?

A. $CH_3CH_2CH_2CH_2CH_2CH_3$

B. $CH_3CH_2CH_2CH_2CH_3$

C. $CH_3CH(CH_3)CH_2CH_3$

D. $CH_3C(CH_3)_2CH_3$

25. Which of the following can be both formed from bromoethane and converted directly into ethanal?

$$CH_3CH_2Br \rightarrow \mathbf{X}$$

$$\mathbf{X} \rightarrow CH_3CHO$$

A. CH_3CH_2OH

B. CH_3OCH_3

C. CH_3COOH

D. $H_2C{=}CHBr$

26. Methane reacts with chlorine in sunlight.

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Which type of reaction occurs?

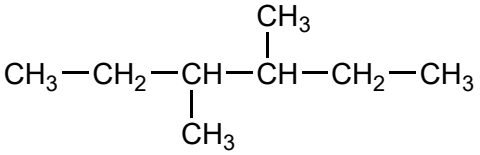
A. free-radical substitution

B. electrophilic substitution

C. nucleophilic substitution

D. electrophilic addition

27. What is the name of this compound using IUPAC rules?



A. 2,3-diethylbutane

B. 2-ethyl-3-methylpentane

C. 3-methyl-4-ethylpentane

D. 3,4-dimethylhexane

28. The following data were recorded for determining the density of three samples of silicon, Si.

Mass / g ±0.01 g	**Volume / cm^3 ±0.1 cm^3**
5.61	2.8
4.32	1.7
6.37	2.8

Which average density value, in $g\,cm^{-3}$, has been calculated to the correct number of significant figures?

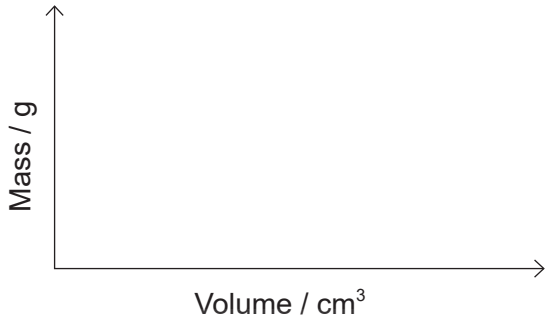
A. 2

B. 2.3

C. 2.27

D. 2.273

29. Data collected from a larger number of silicon samples could also be plotted to determine the density using the following axes.



Which statements are correct?

I. The density is the slope of the graph.
II. The data will show that mass is proportional to volume.
III. The best-fit line should pass through the origin.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

30. What can be deduced from the infrared (IR) spectrum of a compound?

A. Number of hydrogens

B. Number of hydrogen environments

C. Bonds present

D. Molar mass