Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1

Wednesday 22 May 2019 (afternoon)

1 hour

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 **[40 marks]**.

2219–6113

15 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. 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

5. Which of the following transitions in the hydrogen atom emits the least energy?

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

B. $n = 3$ to $n = 1$

C. $n = 4$ to $n = 2$

D. $n = 4$ to $n = 3$

6. How is colour produced in transition metal complexes?

A. Light is absorbed when electrons are promoted between split d-orbitals.

B. Light is emitted when electrons fall between split d-orbitals.

C. Light is absorbed when electrons escape from the complex.

D. Light is emitted when the complex returns to ground state.

7. 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

8. What is the oxidation state of the metal ion and charge of the complex ion in $[Co(NH_3)_4Cl_2]Cl$?

	Oxidation state of metal ion	**Charge of complex ion**
A.	+1	2+
B.	+2	1+
C.	+3	1+
D.	+3	0

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 species has a square planar molecular geometry?

A. SF_4

B. XeF_4

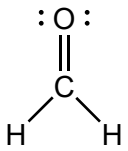
C. CF_4

D. PF_4^+

12. How many sigma (σ) and pi (π) bonds are present in hydrogen cyanide, HCN?

	Sigma (σ)	Pi (π)
A.	1	1
B.	2	2
C.	2	1
D.	1	3

13. What is the hybridization of carbon and oxygen in methanal?



	Hybridization of C	Hybridization of O
A.	sp^2	sp^2
B.	sp^2	sp
C.	sp	sp^2
D.	sp^3	sp^3

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

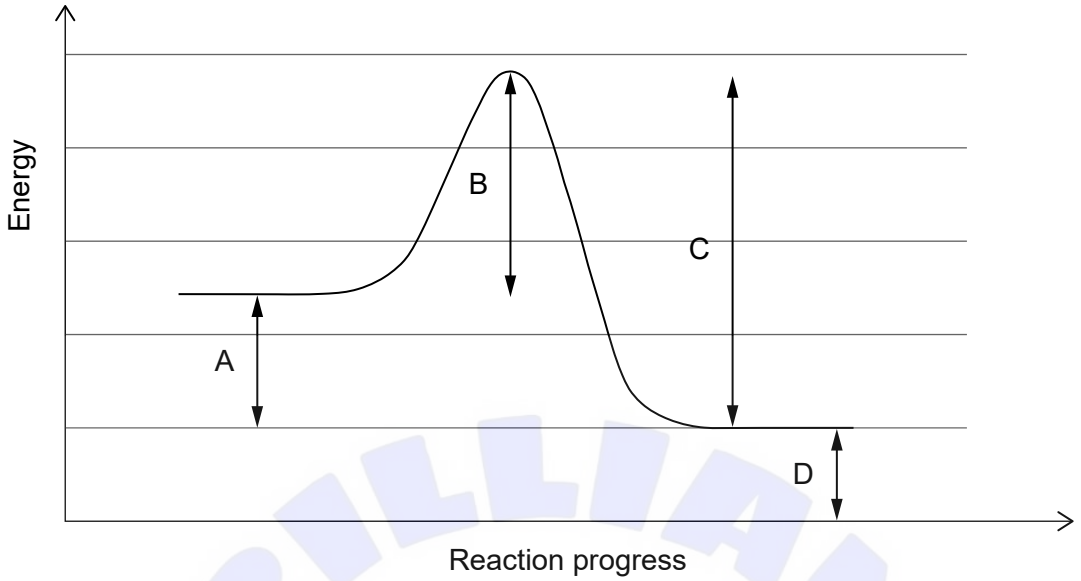
A. [2(1077) + 4(463)] – [2(414) + 3(498)]

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. What is the activation energy of the reverse reaction?



16. Which equation represents lattice enthalpy?

A. $NaCl(g) \rightarrow Na^+(g) + Cl^-(g)$

B. $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$

C. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$

D. $NaCl(s) \rightarrow Na^+(s) + Cl^-(s)$

17. Which change has the greatest increase in entropy?

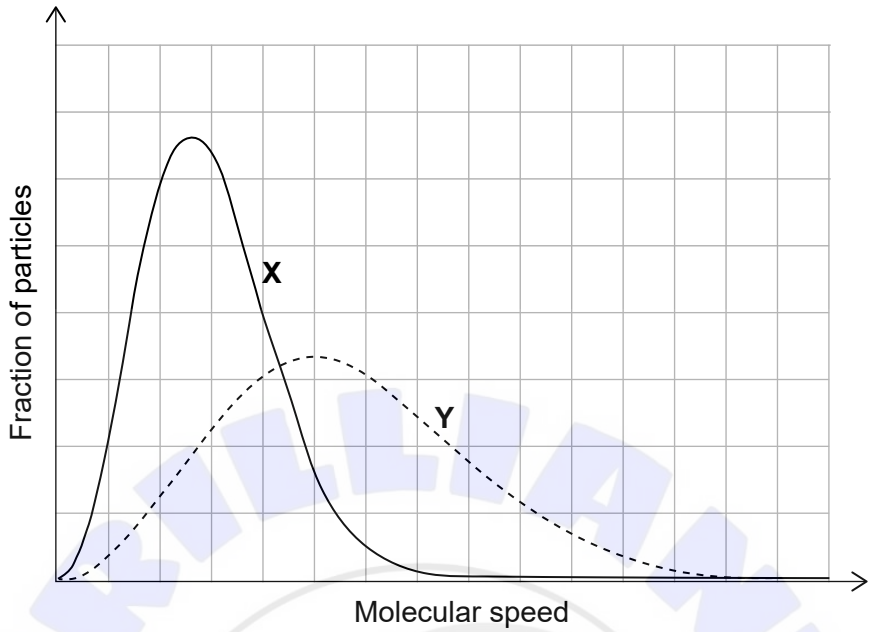
A. $CO_2(s) \rightarrow CO_2(g)$

B. $CO_2(g) \rightarrow CO_2(l)$

C. $CO_2(g) \rightarrow CO_2(s)$

D. $CO_2(l) \rightarrow CO_2(s)$

18. 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.

19. 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

20. Which statement is correct about a catalyst?

A. It decreases the activation energy of the forward reaction but not the reverse.

B. It increases the proportion of products to reactants in an equilibrium.

C. It decreases the enthalpy change of the reaction.

D. It changes the mechanism of the reaction.

21. What is the order with respect to each reactant?

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Initial [NO] / mol dm^{-3}	Initial [Cl_2] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
0.10	0.10	2.5×10^{-6}
0.10	0.20	5.0×10^{-6}
0.20	0.10	10.0×10^{-6}

	Order with respect to NO	Order with respect to Cl_2
A.	0	1
B.	1	1
C.	2	1
D.	2	2

22. Consider the following equilibrium reaction.

$$2N_2O(g) + O_2(g) \rightleftharpoons 4NO(g) \qquad \Delta H = +16\,kJ$$

Which change will move the equilibrium to the right?

A. Decrease in pressure

B. Decrease in temperature

C. Increase in [NO]

D. Decrease in [O_2]

23. Iodine and bromine gases were mixed and allowed to reach equilibrium.

$$I_2(g) + Br_2(g) \rightleftharpoons 2IBr(g)$$

	$[I_2]$	**$[Br_2]$**	**[IBr]**
Initial concentration	0.20	0.20	0.00
Equilibrium concentration	0.10	0.10	x

What is the value of the equilibrium constant?

A. 0.05

B. 1

C. 4

D. 10

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

A. 1

B. 3

C. 11

D. 13

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

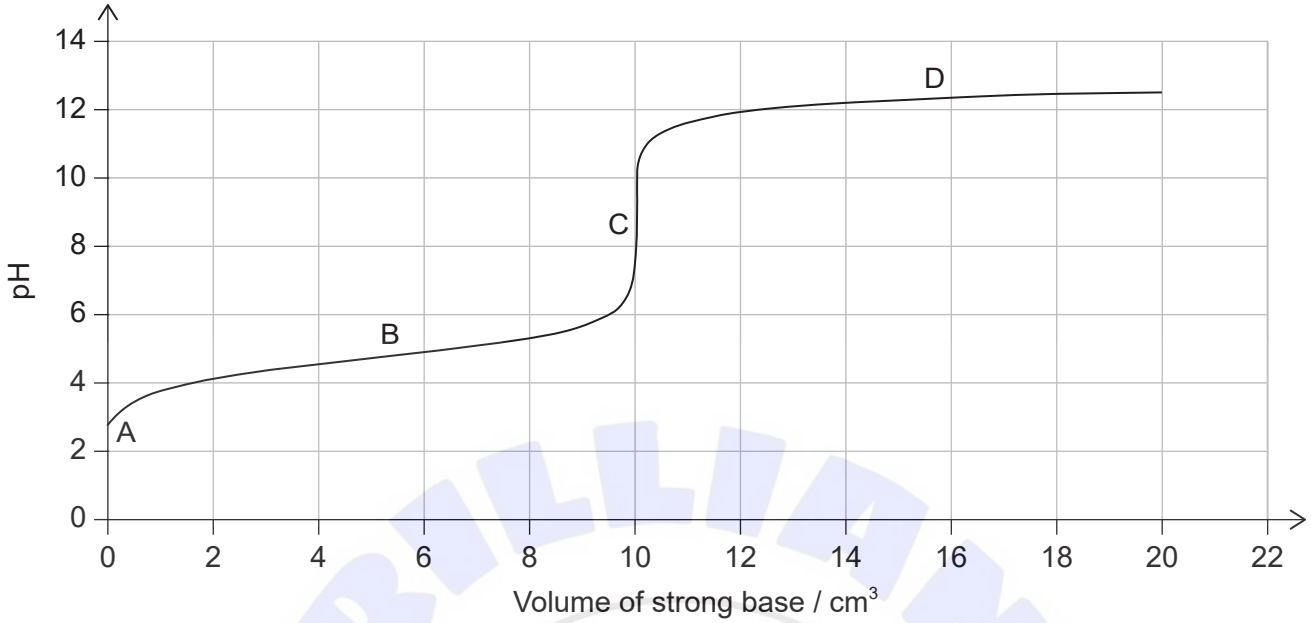
A. methane

B. carbon dioxide

C. nitrogen oxides

D. sulfur dioxide

26. Where is the buffer region for the titration of a weak acid with a strong base?



27. The following equation represents the dissociation of water at 25 °C.

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \qquad \Delta H = +56\,kJ$$

Which changes occur as the temperature increases?

A. $[H_3O^+]$ increases and pH will decrease.

B. $[H_3O^+]$ decreases and pH will increase.

C. $[H_3O^+]$ increases and pH will increase.

D. $[H_3O^+]$ decreases and pH will decrease.

28. Which compound contains sulfur with an oxidation state of +6?

A. SO_2

B. H_2S

C. H_2SO_3

D. H_2SO_4

29. 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.	$Mg^{2+}(aq) + 2e^{-} \rightarrow Mg(s)$	$Ag(s) \rightarrow Ag^{+}(aq) + e^{-}$

30. Consider the following table of standard electrode potentials.

Reaction	$E^{\ominus}$ / V
$Al^{3+}(aq) + 3e^{-} \rightleftharpoons Al(s)$	−1.66
$Pb^{2+}(aq) + 2e^{-} \rightleftharpoons Pb(s)$	−0.13

Which is the strongest oxidizing agent?

A. Pb^{2+}

B. Pb

C. Al^{3+}

D. Al

31. What are the products when concentrated KBr(aq) is electrolysed?

	Anode (positive electrode)	Cathode (negative electrode)
A.	O_2	K
B.	O_2	H_2
C.	Br_2	K
D.	Br_2	H_2

32. 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. $CH_3C(CH_3)_2CH_3$

33. Methane reacts with chlorine in sunlight.

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

Which type of reaction occurs?

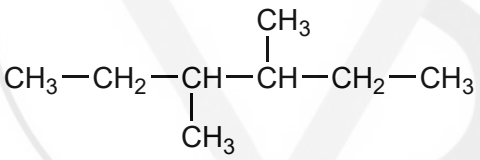
A. free-radical substitution

B. electrophilic substitution

C. nucleophilic substitution

D. electrophilic addition

34. 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

35. What must be present on a nucleophile?

A. Negative charge

B. Lone pair of electrons

C. Positive charge

D. Symmetrical distribution of electrons

36. Which compound exists as two configurational isomers?

A. $CBr_2=CH_2$

B. $CH_2=CHBr$

C. $CHBr_2CH_2Br$

D. CHBr=CHBr

37. Which class of compound is formed when a ketone is reduced?

A. primary alcohol

B. secondary alcohol

C. ether

D. carboxylic acid

38. 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

39. 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

40. Which technique involves breaking covalent bonds when carried out on an organic compound?

A. infrared spectroscopy

B. nuclear magnetic resonance spectroscopy

C. X-ray crystallography

D. mass spectrometry