Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 7 November 2018 (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]**.

11 pages

8818 – 6104

The Periodic Table

Atomic number
Element
Relative atomic mass

	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											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 FeS_2 are required to produce 32 g of SO_2? (A_r: S = 32, O = 16)

$$4FeS_2(s) + 11O_2(g) \rightarrow 2Fe_2O_3(s) + 8SO_2(g)$$

A. 0.25

B. 0.50

C. 1.0

D. 2.0

2. The volume of a sample of gas measured at 27 °C is 10.0 dm^3. What is the temperature when the volume is reduced to 9.0 dm^3 at the same pressure?

A. –3.0 °C

B. 24.3 °C

C. 29.7 °C

D. 57.0 °C

3. 16 g of bromine react with 5.2 g of metal, M, to form MBr_2. What is the relative atomic mass of the metal M? (A_r: Br = 80)

A. 13

B. 26

C. 52

D. 104

4. An antacid tablet containing 0.50 g of $NaHCO_3$ (M_r = 84) is dissolved in water to give a volume of 250 cm^3. What is the concentration, in mol dm^{-3}, of HCO_3^- in this solution?

A. $\frac{0.250 \times 84}{0.50}$

B. $\frac{0.50}{84 \times 0.250}$

C. $\frac{250 \times 84}{0.50}$

D. $\frac{0.50}{84 \times 250}$

5. Which statements are correct for the emission spectrum of hydrogen?

I. The lines converge at higher frequencies.

II. Electron transitions to $n = 2$ are responsible for lines in the visible region.

III. Lines are produced when electrons move from lower to higher energy levels.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

6. Which statement about $^{56}Fe^{3+}$ and $^{54}Fe^{2+}$ is correct?

A. Both have the same numbers of protons and electrons.

B. Both have the same number of protons.

C. Both have the same number of neutrons.

D. Both have the same numbers of protons and neutrons.

7. Which oxides produce an acidic solution when added to water?

I. Al_2O_3 and SiO_2

II. P_4O_6 and P_4O_{10}

III. NO_2 and SO_2

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which species will require the least energy for the removal of one electron?

A. Na^+

B. Mg^+

C. Al^{2+}

D. C^{3+}

9. Which species has the same molecular geometry as SO_3^{2-}?

A. BF_3

B. SO_3

C. PF_3

D. CO_3^{2-}

10. How many lone pairs and bonding pairs of electrons surround the central chlorine atom in ClF_2^+?

	Lone pairs	**Bonding pairs**
A.	0	2
B.	0	4
C.	2	4
D.	2	2

11. Which compound has the highest boiling point?

A. CH_3CHO

B. CH_3CH_2F

C. CH_3OCH_3

D. $CH_3CH_2NH_2$

12. Which molecule is polar?

A. $BeCl_2$

B. BCl_3

C. NCl_3

D. CCl_4

13. Consider the following reactions:

$$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g) \qquad \Delta H^\ominus = -3\,kJ$$
$$Fe(s) + CO_2(g) \rightarrow FeO(s) + CO(g) \qquad \Delta H^\ominus = +11\,kJ$$

What is the $\Delta H^\ominus$ value, in kJ, for the following reaction?

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

A. –25

B. –14

C. +8

D. +19

14. Which is correct when $Ba(OH)_2$ reacts with NH_4Cl?

$$Ba(OH)_2(s) + 2NH_4Cl(s) \rightarrow BaCl_2(aq) + 2NH_3(g) + 2H_2O(l) \qquad \Delta H^\ominus = +164\,kJ\,mol^{-1}$$

	Temperature	**Enthalpy**	**Stability**
A.	increases	products have lower enthalpy than the reactants	products are less stable than the reactants
B.	decreases	products have lower enthalpy than the reactants	products are more stable than the reactants
C.	decreases	products have higher enthalpy than the reactants	products are less stable than the reactants
D.	increases	products have higher enthalpy than the reactants	products are more stable than the reactants

15. Consider the following reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

	Bond enthalpies / kJ mol^{-1} (at 298 K)
H–H	x
N≡N	y
N–H	z

Which calculation gives $\Delta H^{\ominus}$, in kJ, for the forward reaction?

A. $2z - y - 3x$

B. $y + 3x - 2z$

C. $y + 3x - 6z$

D. $6z - y - 3x$

16. Samples of sodium carbonate powder were reacted with separate samples of excess hydrochloric acid.

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow CO_2(g) + 2NaCl(aq) + H_2O(l)$$

Reaction I: 1.0 g Na_2CO_3(s) added to 0.50 mol dm^{-3} HCl(aq)
Reaction II: 1.0 g Na_2CO_3(s) added to 2.0 mol dm^{-3} HCl(aq)

What is the same for reactions I and II?

A. Initial rate of reaction

B. Total mass of CO_2 produced

C. Total reaction time

D. Average rate of production of CO_2

17. What decreases the activation energy of a reaction?

A. Increasing the temperature

B. Adding a catalyst

C. Adding more reactants

D. Increasing collision frequency of reactants

18. Consider the reaction:

$$2N_2O(g) \rightleftharpoons 2N_2(g) + O_2(g)$$

The values of K_c at different temperatures are:

Temperature / K	K_c
838	1.10×10^{-3}
1001	3.80×10^{-1}
1030	8.71×10^{-1}
1053	1.67

Which statement is correct at higher temperature?

A. The forward reaction is favoured.

B. The reverse reaction is favoured.

C. The rate of the reverse reaction is greater than the rate of the forward reaction.

D. The concentration of both reactants and products increase.

19. Which two species act as Brønsted–Lowry acids in the reaction?

$$H_2PO_4^-(aq) + OH^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H_2O(l)$$

A. $HPO_4^{2-}(aq)$ and $OH^-(aq)$

B. $H_2PO_4^-(aq)$ and $HPO_4^{2-}(aq)$

C. $HPO_4^{2-}(aq)$ and $H_2O(l)$

D. $H_2PO_4^-(aq)$ and $H_2O(l)$

20. What is the order of increasing pH for the following solutions of the same concentration?

A. $HCl(aq) < NH_3(aq) < NaOH(aq) < CH_3COOH(aq)$

B. $CH_3COOH(aq) < HCl(aq) < NH_3(aq) < NaOH(aq)$

C. $HCl(aq) < CH_3COOH(aq) < NH_3(aq) < NaOH(aq)$

D. $NaOH(aq) < NH_3(aq) < CH_3COOH(aq) < HCl(aq)$

21. Which is correct for the reaction?

$$P_4(s) + 3H_2O(l) + 3OH^-(aq) \rightarrow PH_3(g) + 3H_2PO_2^-(aq)$$

	Oxidizing agent	Reducing agent
A.	H_2O	P_4
B.	P_4	OH^-
C.	OH^-	P_4
D.	P_4	P_4

22. Which describes the flow of electrons in a voltaic cell?

A. From the cathode (positive electrode) to the anode (negative electrode) through the external circuit

B. From the anode (negative electrode) to the cathode (positive electrode) through the external circuit

C. From the oxidizing agent to the reducing agent through the salt bridge

D. From the reducing agent to the oxidizing agent through the salt bridge

23. Which represents a reduction?

A. SO_3 to SO_4^{2-}

B. Mn_2O_3 to MnO_2

C. H_2O_2 to OH^-

D. CrO_4^{2-} to $Cr_2O_7^{2-}$

24. Which compounds cause the colour of acidified potassium manganate(VII) solution to change from purple to colourless?

I. $CH_3CH_2CH_2CH_2OH$

II. $(CH_3)_3CCH_2OH$

III. $CH_3CH_2CH(OH)CH_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. What is the order of increasing boiling point for the isomers of C_5H_{12}?

A. $CH_3CH_2CH_2CH_2CH_3 < CH_3CH(CH_3)CH_2CH_3 < CH_3C(CH_3)_3$

B. $CH_3C(CH_3)_3 < CH_3CH(CH_3)CH_2CH_3 < CH_3CH_2CH_2CH_2CH_3$

C. $CH_3C(CH_3)_3 < CH_3CH_2CH_2CH_2CH_3 < CH_3CH(CH_3)CH_2CH_3$

D. $CH_3CH(CH_3)CH_2CH_3 < CH_3C(CH_3)_3 < CH_3CH_2CH_2CH_2CH_3$

26. Which is correct for benzene?

A. It readily undergoes addition reactions and decolourises bromine water.

B. It contains alternate single and double carbon–carbon bonds and is planar.

C. Its ^1H NMR spectrum shows six signals and it readily undergoes substitution reactions.

D. Its ^1H NMR spectrum shows one signal and it forms a single C_6H_5Br isomer.

27. Which compounds react to form $CH_3CH_2CH_2COOCH(CH_3)_2$?

A. propanoic acid and propan-2-ol

B. propanoic acid and butan-2-ol

C. butanoic acid and propan-1-ol

D. butanoic acid and propan-2-ol

28. Which is correct for the spectra of organic compounds?

A. Mass spectroscopy provides information about bond vibrations.

B. ^{1}H NMR spectroscopy provides the values of carbon–hydrogen bond lengths.

C. Infrared spectroscopy provides the number of hydrogen atoms.

D. Mass spectroscopy provides information about the structure.

29. What is the ratio of areas under each signal in the ^{1}H NMR spectrum of 2-methylbutane?

A. 6 : 1 : 2 : 3

B. 3 : 3 : 1 : 5

C. 6 : 1 : 5

D. 3 : 3 : 1 : 2 : 3

30. What are the absolute and percentage uncertainties for the change in mass?

Initial mass: 22.35 ±0.05 g
Final mass: 42.35 ±0.05 g

	Absolute uncertainty / g	**Percentage uncertainty**
A.	±0.05	0.1 %
B.	±0.10	0.5 %
C.	±0.05	0.5 %
D.	±0.10	0.1 %