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 – 6107

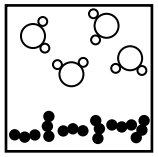
15 pages

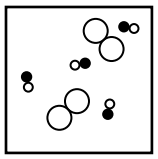
The Periodic Table

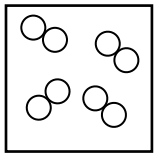
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											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)

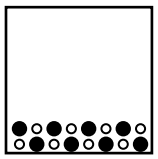
†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (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. Which diagram represents a heterogeneous mixture?

A. 

B. 

C. 

D. 

2. What volume of carbon dioxide, $CO_2(g)$, can be obtained by reacting $1\,dm^3$ of methane, $CH_4(g)$, with $1\,dm^3$ of oxygen, $O_2(g)$?

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

A. $0.5\,dm^3$

B. $1\,dm^3$

C. $2\,dm^3$

D. $6\,dm^3$

3. What is the empirical formula of a hydrocarbon with 75 % carbon and 25 % hydrogen by mass?

A. C_3H

B. CH_2

C. C_2H_6

D. CH_4

4. What is the ground state electron configuration of an atom of chromium, Cr (Z = 24)?

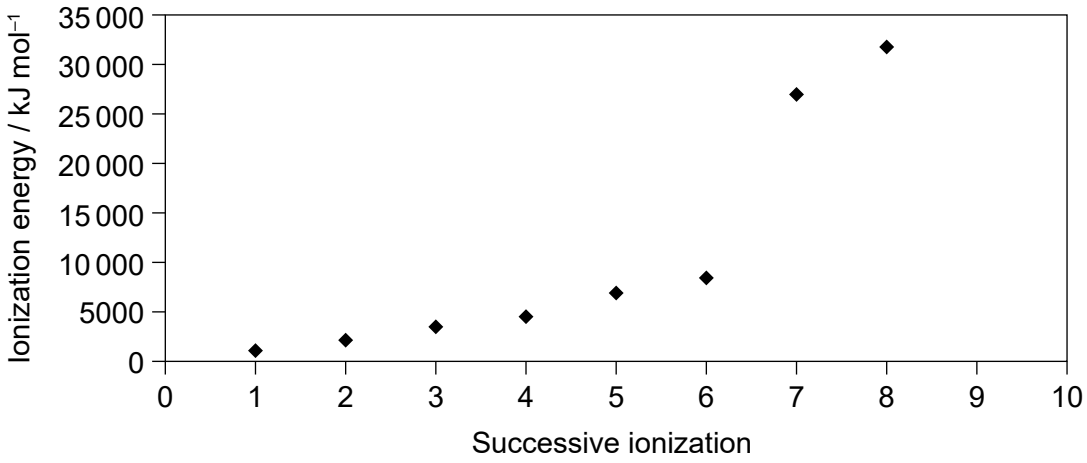
A. $[Ar]3d^6$

B. $[Ar]4s^2 3d^4$

C. $[Ar]4s^1 3d^5$

D. $[Ar]4s^2 4p^4$

5. Which element is represented by the first eight successive ionization energies on the graph?



A. Mg

B. S

C. Cl

D. Ar

6. Which describes an atom of bismuth, Bi (Z = 83)?

	Principal energy level number	Number of valence electrons
A.	5	3
B.	5	5
C.	6	5
D.	6	15

7. Which series represents atoms in order of decreasing atomic radius?

A. N > C > Be > Mg

B. Mg > N > C > Be

C. Be > C > N > Mg

D. Mg > Be > C > N

8. Which electrons are removed from iron (Z = 26) to form iron(II)?

A. two 3d electrons

B. two 4s electrons

C. one 4s electron and one 3d electron

D. two 4p electrons

9. What is the order of increasing boiling point?

A. $CH_3CH_2CH_2CH_3 < CH_3CH(OH)CH_3 < CH_3COCH_3 < CH_3CO_2H$

B. $CH_3CH_2CH_2CH_3 < CH_3COCH_3 < CH_3CH(OH)CH_3 < CH_3CO_2H$

C. $CH_3CO_2H < CH_3COCH_3 < CH_3CH(OH)CH_3 < CH_3CH_2CH_2CH_3$

D. $CH_3CH_2CH_2CH_3 < CH_3COCH_3 < CH_3CO_2H < CH_3CH(OH)CH_3$

10. What is the IUPAC name of $NiCO_3$?

A. nickel(II) carbonate

B. nickel carbonate

C. nickel(I) carbonate

D. nitrogen(I) carbonate

11. Which combination corresponds to a strong metallic bond?

	Charge on the metal ion	Radius of ion
A.	large	large
B.	large	small
C.	small	small
D.	small	large

12. Which species has delocalized electrons?

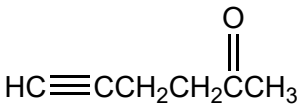
A. OH^-

B. H_2CO

C. CO_2

D. CO_3^{2-}

13. How many carbon atoms are sp^3, sp^2 and sp hybridized in the molecule?



	sp^3	sp^2	sp
A.	3	1	2
B.	2	1	3
C.	3	2	1
D.	3	2	2

14. When equal masses of X and Y absorb the same amount of energy, their temperatures rise by 5 °C and 10 °C respectively. Which is correct?

A. The specific heat capacity of X is twice that of Y.

B. The specific heat capacity of X is half that of Y.

C. The specific heat capacity of X is one fifth that of Y.

D. The specific heat capacity of X is the same as Y.

15. What is the enthalpy change of reaction for the following equation?

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l) \qquad \Delta H = x$$

$$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H = y$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H = z$$

A. $x + y + z$

B. $-x - y + z$

C. $x - y - z$

D. $x - y + z$

16. Which is correct for the reaction $H_2O(g) \rightarrow H_2O(l)$?

A. Enthalpy increases and entropy increases.

B. Enthalpy decreases and entropy increases.

C. Enthalpy increases and entropy decreases.

D. Enthalpy decreases and entropy decreases.

17. Which equation represents the standard enthalpy of atomization of bromine, Br_2?

A. $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

B. $Br_2(l) \rightarrow 2Br(g)$

C. $Br_2(l) \rightarrow 2Br(l)$

D. $\frac{1}{2}Br_2(l) \rightarrow Br(l)$

18. Which properties can be monitored to determine the rate of the reaction?

$$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$$

I. change in volume
II. change in temperature
III. change in colour

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

19. Which conditions are required for the reaction between two molecules?

I. a collision
II. $E \geq E_a$
III. proper orientation

A. I and II only

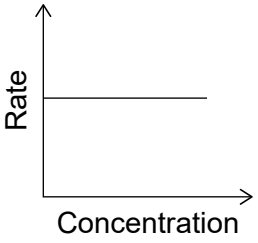
B. I and III only

C. II and III only

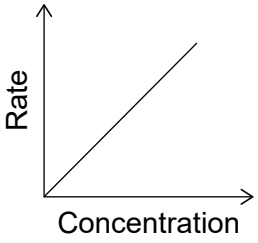
D. I, II and III

20. Which graph is obtained from a first order reaction?

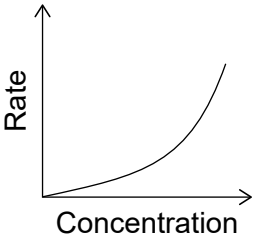
A.



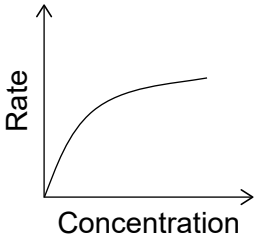
B.



C.



D.



21. Which is correct for the reaction mechanism shown?

$2A \rightarrow B + 2C$ slow
$B + C \rightarrow D + E$ fast
$C + D \rightarrow E + F$ fast

	Equation of overall reaction	Rate equation
A.	$2A \rightarrow E + F$	rate $= k[A]^2$
B.	$2A \rightarrow 2E + F$	rate $= k[C][D]$
C.	$2A + B + 2C + D \rightarrow 2E + F$	rate $= k[A]^2[B][C]^2[D]$
D.	$2A \rightarrow 2E + F$	rate $= k[A]^2$

22. K_c for $2N_2O(g) \rightleftharpoons 2N_2(g) + O_2(g)$ is 7.3×10^{34}.

What is K_c for the following reaction, at the same temperature?

$$N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons N_2O(g)$$

A. 7.3×10^{34}

B. $\frac{1}{\sqrt{7.3 \times 10^{34}}}$

C. $\frac{2}{7.3 \times 10^{34}}$

D. $\frac{1}{2 \times 7.3 \times 10^{34}}$

23. Which is correct for a reaction with a positive change in Gibbs free energy, $\Delta G^{\ominus}$?

A. The formation of reactants is favoured.

B. The formation of products is favoured.

C. The reaction is at equilibrium.

D. The reaction is spontaneous.

24. Which solution is basic at 25 °C?

$$K_w = 1.0 \times 10^{-14}$$

A. $[H^+] = 1.0 \times 10^{-3}\,\text{mol}\,\text{dm}^{-3}$

B. $[OH^-] = 1.0 \times 10^{-13}\,\text{mol}\,\text{dm}^{-3}$

C. solution of $\text{pH} = 4.00$

D. $[H_3O^+] = 1.0 \times 10^{-13}\,\text{mol}\,\text{dm}^{-3}$

25. With which do most acids react?

I. sodium hydrogen carbonate
II. magnesium
III. calcium sulfate

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26. Which is a Lewis acid but not a Brønsted–Lowry acid?

A. $AlCl_3$

B. CH_3CO_2H

C. HF

D. CCl_4

27. Which has the strongest conjugate base?

A. HCOOH ($K_a = 1.8 \times 10^{-4}$)

B. HNO_2 ($K_a = 7.2 \times 10^{-4}$)

C. HCN ($K_a = 6.2 \times 10^{-10}$)

D. HIO_3 ($K_a = 1.7 \times 10^{-1}$)

28. Which product will be obtained at the anode (positive electrode) when molten NaCl is electrolysed?

A. Na (l)

B. Cl (g)

C. Cl_2 (g)

D. Na (s)

29. Where does oxidation occur in a voltaic cell?

A. positive electrode and anode

B. negative electrode and anode

C. positive electrode and cathode

D. negative electrode and cathode

30. Which factors affect the amount of product formed at the cathode during electrolysis of molten salts?

I. current
II. time
III. charge on the cation

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

31. Which is **not** a requirement of the standard hydrogen electrode (SHE)?

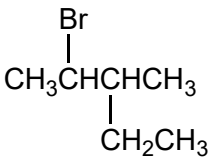
A. $V = 1\,\text{dm}^3$

B. $p(\text{H}_2) = 100\,\text{kPa}$

C. use of platinum as the electrode material

D. $[\text{H}_3\text{O}^+] = 1\,\text{mol}\,\text{dm}^{-3}$

32. What is the IUPAC name of the following molecule?



A. 2-bromo-3-ethylbutane

B. 3-methyl-4-bromopentane

C. 2-ethyl-3-bromobutane

D. 2-bromo-3-methylpentane

33. Which is a major product of the electrophilic addition of hydrogen chloride to propene?

A. $ClCH_2CH{=}CH_2$

B. $CH_3CH(Cl)CH_3$

C. $CH_3CH_2CH_2Cl$

D. $CH_3CH{=}CHCl$

34. Which alcohol would produce a carboxylic acid when heated with acidified potassium dichromate(VI)?

A. propan-2-ol

B. butan-1-ol

C. 2-methylpropan-2-ol

D. pentan-3-ol

35. Which solvent is aprotic?

A. H_2O

B. $C_6H_5CH_3$

C. CH_3OH

D. CH_3NH_2

36. Which statement is **not** correct regarding benzene?

A. It is planar.

B. The ring contains delocalized electrons.

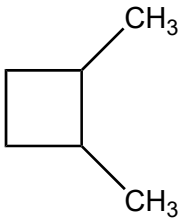
C. It always reacts in the same way as alkenes.

D. The carbon–carbon bond has a bond order of 1.5.

37. Which compound can exist as *cis*- and *trans*-isomers?

A. $CH_2=CHCH_2CH_3$

B. $CBr_2=CF_2$

C. 

D. 

38. How should a measurement of 5.00 g from a balance be recorded?

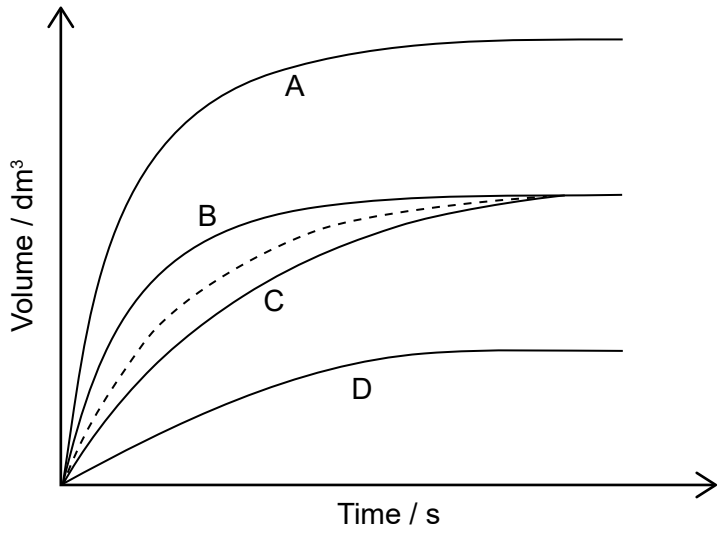
A. 5.00 ± 0.1 g

B. 5.00 ± 0.01 g

C. 5.00 ± 1 g

D. 5.00 ± 0.001 g

39. The dotted line represents the formation of oxygen, $O_2(g)$, from the uncatalysed complete decomposition of hydrogen peroxide, $H_2O_2(aq)$.



Which curve represents a catalysed reaction under the same conditions?

40. Which can be identified using infrared (IR) spectroscopy?

A. functional groups

B. molar mass

C. 3-D configuration

D. bond angle