Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 9 November 2022 (morning)

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]**.

8822–6104

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																	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)

Atomic number
Element
Relative atomic mass

†	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 oxygen atoms are present in 0.0500 mol $Ba(OH)_2 \cdot 8H_2O$?

$$N_A = 6.02 \times 10^{23}$$

A. 3.01×10^{23}

B. 6.02×10^{23}

C. 3.01×10^{24}

D. 6.02×10^{24}

2. What is the change of state for a gas to a solid?

A. Condensation

B. Deposition

C. Freezing

D. Sublimation

3. How many moles of carbon dioxide are produced by the complete combustion of 7.0 g of ethene, $C_2H_4(g)$?

$$M_r = 28$$

A. 0.25

B. 0.5

C. 0.75

D. 1.0

4. Which is a possible empirical formula for a substance with $M_r = 42$?

A. CH

B. CH_2

C. C_3H_6

D. C_3H_8

5. Which quantities are different between two species represented by the notation $^{128}_{52}Te$ and $^{128}_{53}I^-$?

A. The number of protons only

B. The number of protons and electrons only

C. The number of protons and neutrons only

D. The number of protons, neutrons and electrons

6. What is the relative atomic mass of a sample of chlorine containing 70 % of the ^{35}Cl isotope and 30 % of the ^{37}Cl isotope?

A. 35.4

B. 35.5

C. 35.6

D. 35.7

7. Which elements are considered to be metalloids?

I. Gallium

II. Germanium

III. Arsenic

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which property of elements increases down a group but decreases across a period?

A. Atomic radius

B. Electronegativity

C. Ionic radius

D. Ionization energy

9. Which molecule can be represented by resonance structures?

A. H_2S

B. HNO_3

C. H_2O_2

D. HClO

10. Which molecule is polar?

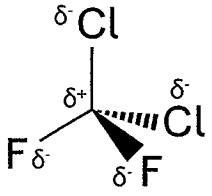
A. BeH_2

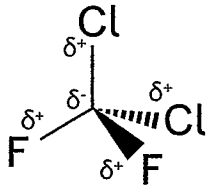
B. AlH_3

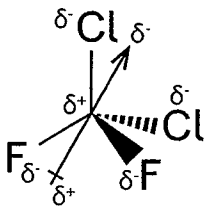
C. PH_3

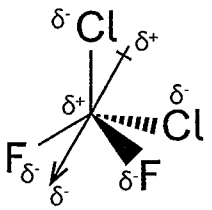
D. SiH_4

11. Which structure of CF_2Cl_2 is shown with correct bond and molecular dipoles?

A. 

B. 

C. 

D. 

12. Alloying a metal with a metal of smaller atomic radius can disrupt the lattice and make it more difficult for atoms to slide over each other. Which property will increase as a result?

A. Electrical conductivity

B. Ductility

C. Malleability

D. Strength

13. Chlorofluorocarbons (CFCs) contain bonds of the following lengths:

C—C = 1.54×10^{-10} m

C—F = 1.38×10^{-10} m

C—Cl = 1.77×10^{-10} m

What is the order of **increasing** bond strength in the CFC molecule?

A. C—C < C—F < C—Cl

B. C—C < C—Cl < C—F

C. C—Cl < C—C < C—F

D. C—F < C—C < C—Cl

14. What is the value for enthalpy of formation of methane from the given enthalpies of combustion?

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -394\,kJ\,mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -286\,kJ\,mol^{-1}$

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta H = -891\,kJ\,mol^{-1}$

A. $(-394 - 286 - 891)\,kJ\,mol^{-1}$

B. $(-394 - (2 \times 286) - 891)\,kJ\,mol^{-1}$

C. $(-394 - 286 + 891)\,kJ\,mol^{-1}$

D. $(-394 - (2 \times 286) + 891)\,kJ\,mol^{-1}$

15. Which statement best describes heat?

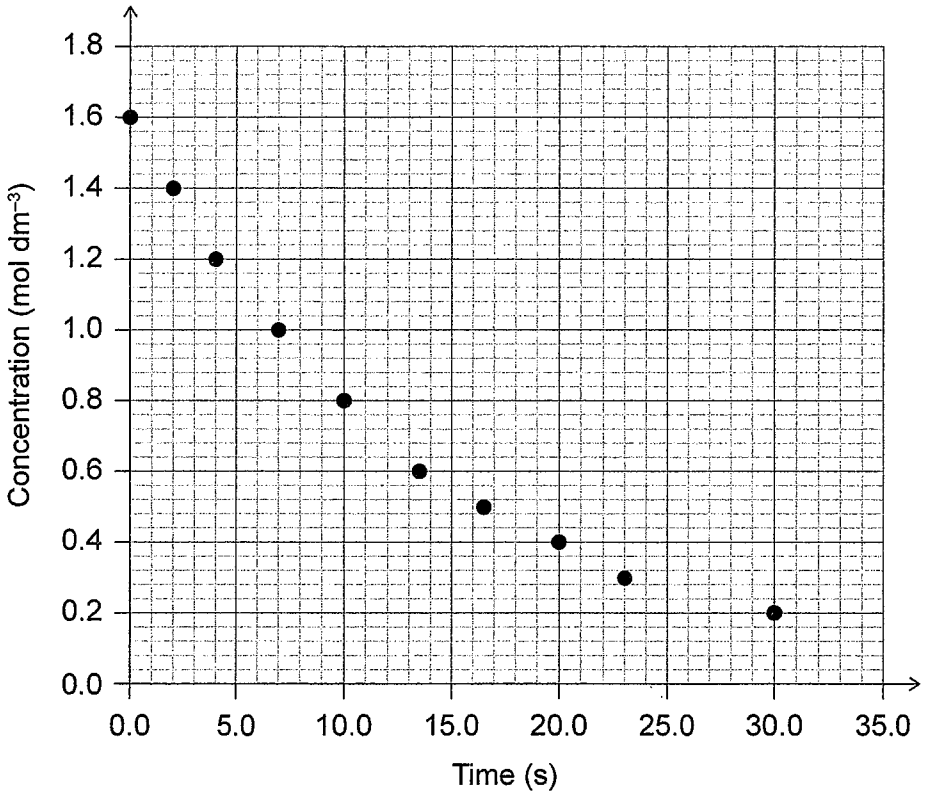
A. A quantity of potential energy of particles

B. A quantity of average kinetic energy of particles

C. A quantity of energy transferred between particles

D. A quantity of the total energy held by particles

16. What initial rate of reaction can be determined from the graph?



A. 0.1 mol dm^{-3} s^{-1}

B. 0.2 mol dm^{-3} s^{-1}

C. 1.0 mol dm^{-3} s^{-1}

D. 1.6 mol dm^{-3} s^{-1}

17. Which changes would increase the rate of an exothermic reaction?

	Temperature	Particle size
A.	Increase	Decrease
B.	Increase	Increase
C.	Decrease	Increase
D.	Decrease	Decrease

18. The exothermic reaction $I_2(g) + 3Cl_2(g) \rightleftharpoons 2ICl_3(g)$ is at equilibrium in a fixed volume. What is correct about the reaction quotient, Q, and shift in position of equilibrium the instant temperature is raised?

A. $Q > K$, equilibrium shifts right towards products.

B. $Q > K$, equilibrium shifts left towards reactants.

C. $Q < K$, equilibrium shifts right towards products.

D. $Q < K$, equilibrium shifts left towards reactants.

19. Equal volumes of 0.10 mol dm^{-3} weak acid and strong acid are titrated with 0.10 mol dm^{-3} NaOH solution. Which of these is the same for the two acids?

A. Initial pH

B. Heat evolved in the neutralization

C. Volume of NaOH for complete neutralization

D. Initial electrical conductivity

20. Which species has the weakest conjugate base?

A. HCl

B. NH_4^+

C. HCO_3^-

D. H_2O

21. What occurs during the operation of a voltaic cell based on the given reaction?

$$2Cr(s) + 3Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Fe(s)$$

	External circuit	Ion movement in solution
A.	Electrons move from Cr to Fe	$Fe^{2+}(aq)$ move away from Fe(s)
B.	Electrons move from Cr to Fe	$Fe^{2+}(aq)$ move toward Fe(s)
C.	Electrons move from Fe to Cr	$Cr^{3+}(aq)$ move away from Cr(s)
D.	Electrons move from Fe to Cr	$Cr^{3+}(aq)$ move toward Cr(s)

22. Which substance is the reducing agent in the given reaction?

$$H^{+}(aq) + 2H_2O(l) + 2MnO_4^{-}(aq) + 5SO_2(g) \rightarrow 2Mn^{2+}(aq) + 5HSO_4^{-}(aq)$$

A. H^{+}

B. H_2O

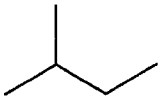
C. MnO_4^{-}

D. SO_2

23. Which combination is correct regarding the anode and electron flow in an electrolytic cell?

	Polarity of anode	Movement of electrons in external circuit
A.	Positive electrode	Anode to cathode
B.	Positive electrode	Cathode to anode
C.	Negative electrode	Anode to cathode
D.	Negative electrode	Cathode to anode

24. Which are isomers of C_5H_{12}?

I. 

II. 

III. 

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. Which homologous series has the general formula $C_nH_{2n}O$ $(n > 2)$?

A. Alcohols

B. Carboxylic acids

C. Ethers

D. Ketones

26. Which conditions best favour oxidation of primary alcohols directly to carboxylic acids?

A. Excess acidified potassium dichromate (VI) and distillation

B. Excess acidified potassium dichromate (VI) and reflux

C. Few drops of acidified potassium dichromate (VI) and distillation

D. Few drops of acidified potassium dichromate (VI) and reflux

27. What are nucleophiles most likely to react with?

A. Alkenes

B. Benzene

C. Alkanes

D. Halogenoalkanes

28. What combination is the most effective for reducing random and systematic errors?

	Reduce random error	Reduce systematic error
A.	Repeat trials	Repeat trials
B.	Recalibrate equipment	Recalibrate equipment
C.	Repeat trials	Recalibrate equipment
D.	Recalibrate equipment	Repeat trials

29. A well tested scientific idea which has been used to make predictions cannot explain a particular event. Which statement describes the scientific approach to this dilemma?

A. Hypothesis should be discarded.

B. Hypothesis should be revised.

C. Theory should be discarded.

D. Theory should be revised.

30. What information about 2-hydroxybutanoic acid can be inferred through mass spectrometry, MS, infrared spectroscopy, IR, and proton nuclear magnetic resonance spectroscopy, ^{1}H NMR?

	MS	IR	^{1}H NMR
A.	$M = 104\,g\,mol^{-1}$.	Compound contains carboxyl and hydroxyl groups.	The hydroxyl group is on the 2nd, rather than 4th carbon.
B.	$M = 104\,g\,mol^{-1}$.	The hydroxyl group is on the 2nd, rather than 4th carbon.	Compound contains carboxyl and hydroxyl groups.
C.	Compound contains carboxyl and hydroxyl groups.	$M = 104\,g\,mol^{-1}$.	The hydroxyl group is on the 2nd, rather than 4th carbon.
D.	Compound contains carboxyl and hydroxyl groups.	The hydroxyl group is on the 2nd, rather than 4th carbon.	$M = 104\,g\,mol^{-1}$.