Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Thursday 5 November 2020 (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]**.

8820 – 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			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. What is the molar mass, in $g\,mol^{-1}$, of a compound if 0.200 mol of the compound has a mass of 13.2 g?

A. 66.0

B. 66

C. 26.4

D. 26

2. What is the number of carbon atoms in 12 g of ethanoic acid CH_3COOH, $M_r = 60$?

A. 0.20

B. 2.0

C. 1.2×10^{23}

D. 2.4×10^{23}

3. Which of these molecular formulae are also empirical formulae?

I. C_2H_6O

II. $C_2H_4O_2$

III. C_5H_{12}

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

4. Which volume of ethane gas, in cm^3, will produce 40 cm^3 of carbon dioxide gas when mixed with 140 cm^3 of oxygen gas, assuming the reaction goes to completion?

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$$

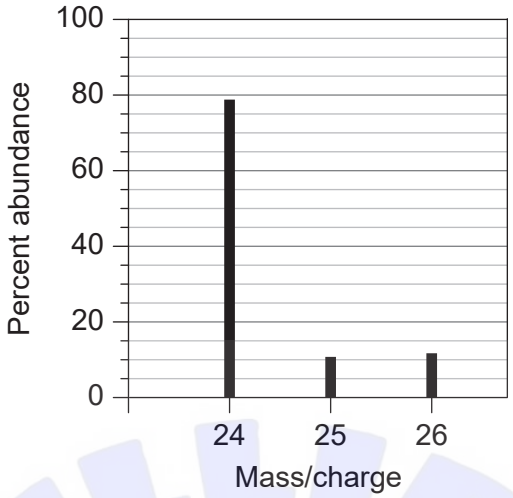
A. 10

B. 20

C. 40

D. 80

5. What is the relative atomic mass, A_r, of an element with this mass spectrum?



A. 24.0

B. 24.3

C. 24.9

D. 25.0

6. What is the maximum number of electrons that can occupy the 4th main energy level in an atom?

A. 8

B. 14

C. 18

D. 32

7. Which of the following shows a general increase across period 3 from Na to Cl?

A. Ionic radius

B. Atomic radius

C. Ionization energy

D. Melting point

8. Which oxide will dissolve in water to give the solution with the lowest pH?

A. P_4O_{10}

B. SiO_2

C. Al_2O_3

D. MgO

9. Which formula is correct?

A. NH_4PO_4

B. $(NH_4)_2PO_4$

C. $(NH_4)_3PO_4$

D. $(NH_4)_3(PO_4)_2$

10. Which molecule is most polar?

A. CHF_3

B. CF_4

C. $CClF_3$

D. CCl_4

11. Which combination correctly describes the geometry of the carbonate ion, CO_3^{2-}?

	Electron domain geometry around C	**Molecular geometry around C**
A.	Trigonal planar	Trigonal pyramidal
B.	Tetrahedral	Trigonal planar
C.	Trigonal planar	Trigonal planar
D.	Tetrahedral	Trigonal pyramidal

12. Which series shows the correct order of metallic bond strength from strongest to weakest?

A. $Na > K > Rb > Mg$

B. $Mg > Rb > K > Na$

C. $Rb > K > Na > Mg$

D. $Mg > Na > K > Rb$

13. Which equation shows the enthalpy of formation, ΔH_f, of ethanol?

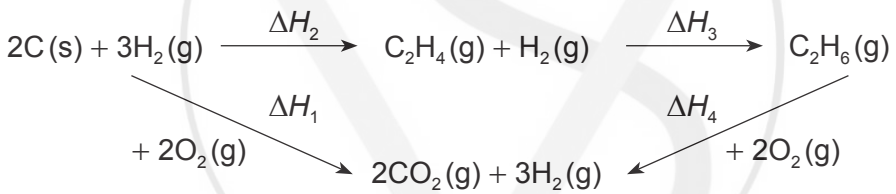
A. $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

B. $4C(s) + 6H_2(g) + O_2(g) \rightarrow 2C_2H_5OH(g)$

C. $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

D. $4C(s) + 6H_2(g) + O_2(g) \rightarrow 2C_2H_5OH(l)$

14. Which combination will give you the enthalpy change for the hydrogenation of ethene to ethane, ΔH_3?



A. $-\Delta H_2 + \Delta H_1 - \Delta H_4$

B. $\Delta H_2 - \Delta H_1 + \Delta H_4$

C. $\Delta H_2 + \Delta H_1 - \Delta H_4$

D. $-\Delta H_2 - \Delta H_1 + \Delta H_4$

15. What is the H−H bond enthalpy, in $kJ\,mol^{-1}$, in the H_2 molecule?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

$$\Delta H_f(H_2O) = x \text{ kJ mol}^{-1}$$

Bond	Bond enthalpy / $kJ\,mol^{-1}$
O=O	y
O–H	z

A. $x - y + 4z$

B. $\frac{1}{2}(x - y + 4z)$

C. $x - y + 2z$

D. $\frac{1}{2}(x - y + 2z)$

16. Which apparatus can be used to monitor the rate of this reaction?

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

I. A pH meter

II. A gas syringe

III. A colorimeter

A. I and II only

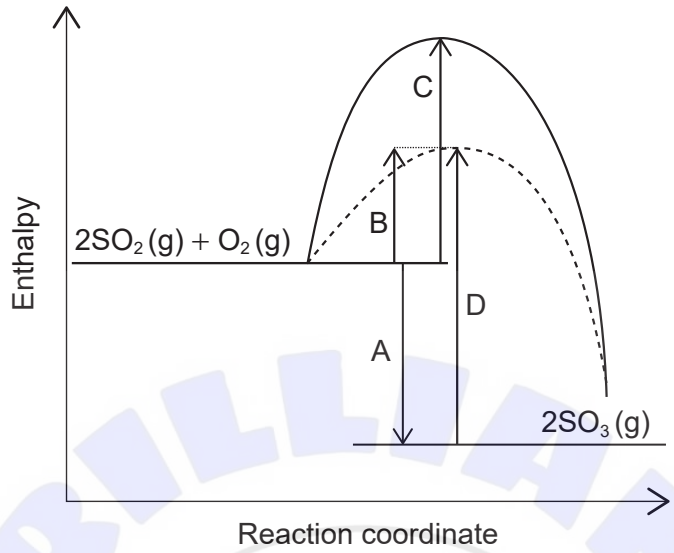
B. I and III only

C. II and III only

D. I, II and III

17. Which arrow shows the activation energy of the uncatalysed forward reaction for this equilibrium?

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196\ kJ\,mol^{-1}$$



18. What is correct when temperature increases in this reaction at equilibrium?

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g) \qquad \Delta H^{\ominus} = +75.5\,kJ$$

	Position of equilibrium	Equilibrium constant, K_c
A.	Shifts left	Unchanged
B.	Shifts left	Decreases
C.	Shifts right	Unchanged
D.	Shifts right	Increases

19. Which substance will **not** produce copper(II) chloride when added to dilute hydrochloric acid?

A. $Cu(s)$

B. $Cu(OH)_2(s)$

C. $CuCO_3(s)$

D. $CuO(s)$

20. Which of these acids has the weakest conjugate base?

A. HCl

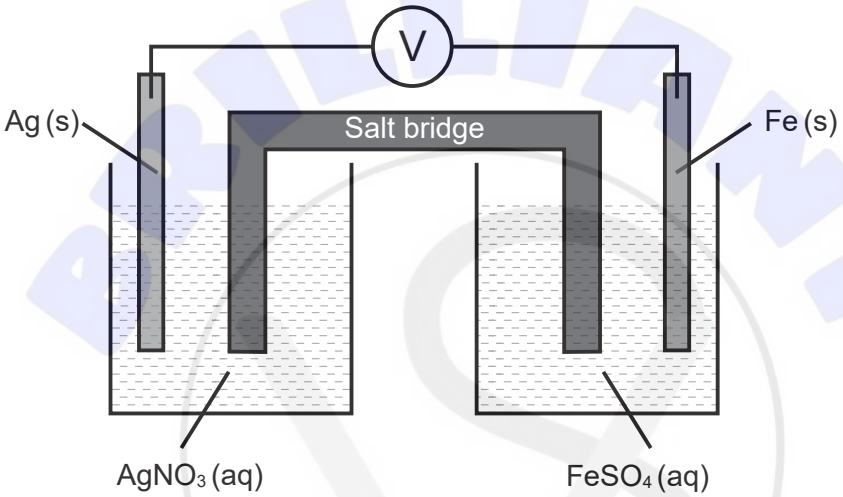
B. CH_3COOH

C. NH_4Cl

D. C_6H_5COOH

21. Iron is a stronger reducing agent than silver.

What is correct when this voltaic cell is in operation?



	Anode (negative electrode)	Cathode (positive electrode)	Direction of electron flow in wire
A.	Ag	Fe	right to left
B.	Ag	Fe	left to right
C.	Fe	Ag	left to right
D.	Fe	Ag	right to left

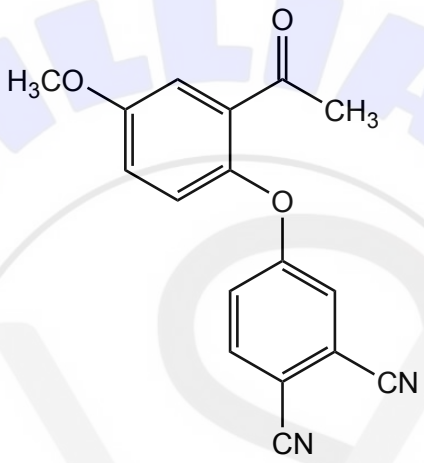
22. What is correct in an electrolytic cell?

	Electrode	Process at this electrode	Electrons lost or gained at this electrode
A.	Anode (positive)	Oxidation	Gained
B.	Anode (positive)	Reduction	Lost
C.	Cathode (negative)	Oxidation	Lost
D.	Cathode (negative)	Reduction	Gained

23. What are the oxidation states of oxygen?

	O_2	OF_2	H_2O_2
A.	–2	–2	–2
B.	0	–2	–1
C.	0	+2	–1
D.	–2	+2	–2

24. Which functional groups are present in this molecule?



A. carbonyl, ether, nitrile

B. carbonyl, ester, nitrile

C. carboxyl, ether, amine

D. carboxyl, ester, amine

25. Which molecule will decolorize bromine water in the dark?

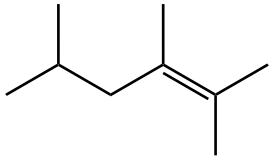
A. cyclohexane

B. hexane

C. hex-1-ene

D. hexan-1-ol

26. What is the IUPAC name of this molecule?



A. 1,1,2,4-tetramethylpent-1-ene

B. 2,4,5-trimethylhex-4-ene

C. 2,4,5,5-tetramethylpent-4-ene

D. 2,3,5-trimethylhex-2-ene

27. Which mechanism does benzene most readily undergo?

A. Nucleophilic substitution

B. Electrophilic substitution

C. Electrophilic addition

D. Free radical substitution

28. A student obtained the following data to calculate q, using $q = mc\Delta T$.

$$m = 20.0\,\text{g} \pm 0.2\,\text{g}$$

$$\Delta T = 10\,^{\circ}\text{C} \pm 1\,^{\circ}\text{C}$$

$$c = 4.18\,\text{J g}^{-1}\,\text{K}^{-1}$$

What is the percentage uncertainty in the calculated value of q?

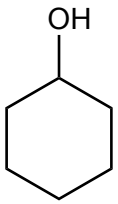
A. 0.2

B. 1.2

C. 11

D. 14

29. What is the index of hydrogen deficiency (IHD) in cyclohexanol?



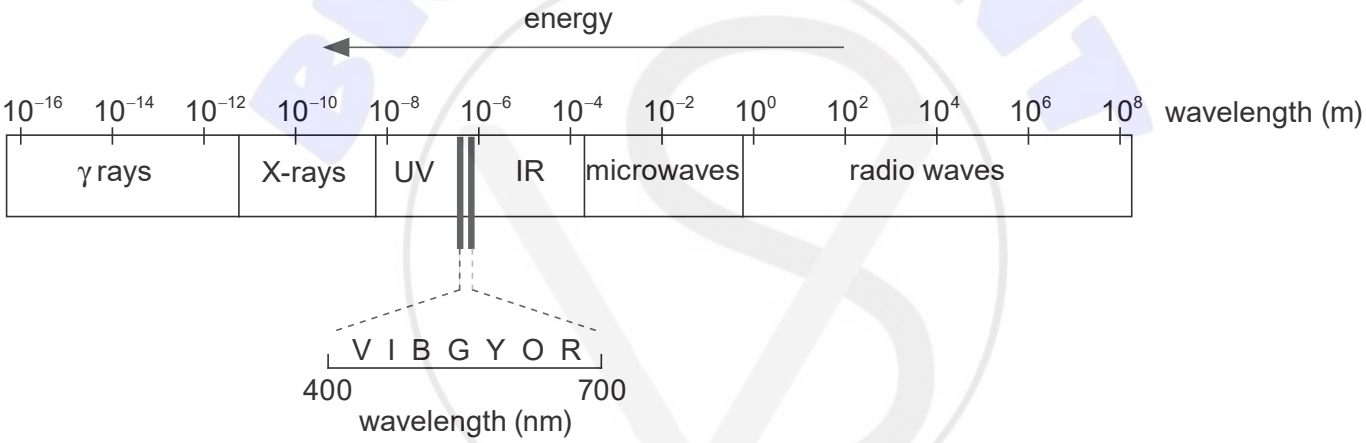
A. 0

B. 1

C. 2

D. 3

30. Which region of the electromagnetic spectrum is used to identify hydrogen environments in a molecule?



A. X-ray

B. UV

C. IR

D. radio waves