Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

2 November 2023

Zone A morning | **Zone B** morning | **Zone C** 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]**.

8823 – 6110

12 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																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01				Atomic number **Element** Relative atomic mass							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)

8823–6110

1. Which hydrocarbon would produce equal numbers of moles of CO_2 and H_2O upon complete combustion?

A. CH_4

B. C_2H_2

C. C_3H_8

D. C_4H_8

2. Metal M reacts with 16.0 g of sulfur to produce 26.0 g of the compound MS_2. What is the relative atomic mass of M?

A. 5

B. 10

C. 20

D. 40

3. 64 g of methane and 96 g of oxygen are reacted according to the equation.

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

What would be found in the reaction vessel at completion of the reaction?

A. $CO_2(g)$ and $H_2O(l)$ only

B. $O_2(g)$, $CO_2(g)$ and $H_2O(l)$ only

C. $CH_4(g)$, $CO_2(g)$ and $H_2O(l)$ only

D. $CH_4(g)$, $O_2(g)$, $CO_2(g)$ and $H_2O(l)$

4. Ammonia reacts with oxygen to produce nitrogen (II) oxide and water.

$$\_\_\_ NH_3(g) + \_\_\_ O_2(g) \rightarrow \_\_\_ NO(g) + \_\_\_ H_2O(l).$$

What is the NH_3:O_2 ratio in the balanced equation?

A. 2:5

B. 4:5

C. 1:1

D. 2:1

5. Gallium ($A_r = 69.72$) consists of two stable isotopes, Ga-69 and Ga-71. What is the relative abundance of Ga-71?

A. 36 %

B. 40 %

C. 60 %

D. 64 %

6. Which electron configuration represents a d-block element in the ground state?

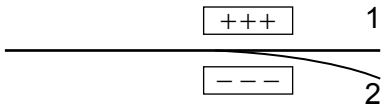
A. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^1$

B. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

C. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$

D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10} 4p^1$

7. A beam containing two different kinds of particles is passed through oppositely charged plates with the results shown in the diagram.



What conclusion can be drawn from this observation?

A. Particle 1 has a larger mass than particle 2.

B. Particle 2 has a larger mass than particle 1.

C. Particle 1 is positively charged.

D. Particle 2 is positively charged.

8. Which factor generally increases when first ionization energy increases?

A. Atomic radius

B. Electronegativity

C. Metallic character

D. Nuclear charge

9. The periodic table provided shows 118 elements. Which group of elements would a new element with atomic number 119 be most similar to?

A. Alkali metals

B. Halogens

C. Lanthanoids and actinoids

D. Noble gases

10. The formula for praseodymium phosphate is $PrPO_4$. What is the formula for praseodymium oxide?

A. Pr_2O

B. PrO

C. Pr_2O_3

D. PrO_2

11. For which molecule can resonance structures be used to describe the bonding?

A. HCN

B. H_2CO_3

C. PCl_3

D. SO_2

12. What are the electron domain and molecular geometries of SO_3?

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

13. Which substance has high volatility in its pure state **and** high electrical conductivity in aqueous solutions?

A. C_6H_5Cl

B. HCl

C. NaCl

D. HCN

14. Which reactions release heat?

I. $C(s) + O_2(g) \rightarrow CO_2(g)$

II. $Na^+(g) + e^- \rightarrow Na(g)$

III. $NH_3(g) \rightarrow NH_3(l)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

15. Which expression represents the calculation used to obtain the $\Delta H^{\ominus}$ value for the conversion of oxygen to one mole of ozone (O_3)?

		$\Delta H^{\ominus}$, kJ
Eqn (i)	$2CO_2 \rightarrow 2CO + O_2$	+566
Eqn (ii)	$3CO + O_3 \rightarrow 3CO_2$	–992

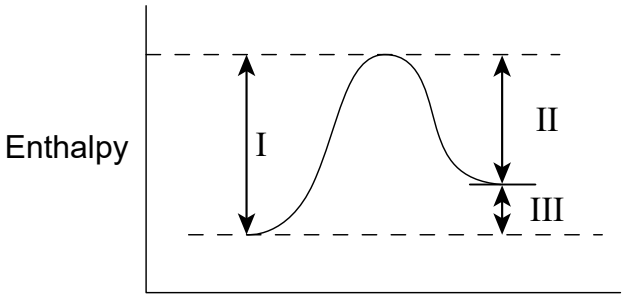
A. $-566 - 992$

B. $-566 + 992$

C. $1.5 \times (-566) + 992$

D. $1.5 \times (-566) - 992$

16. Which expression represents the calculation of ΔH?



A. I–II

B. II–I

C. I–III

D. II–III

17. Which statement describes a role that a catalyst might have in increasing the rate of reaction by providing an alternative mechanism?

A. It increases frequency of collisions between molecules

B. It increases energy of collisions between molecules

C. It increases proportion of molecules colliding in correct orientation

D. It increases proportion of molecules with a given energy

18. Which of the following equilibria would shift left with an increase in pressure?

A. $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$

B. $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$

C. $NO(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO_2(g)$

D. $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(l)$

19. What is the correct way to express the formula for the conjugate base of ethanoic acid?

A. $^{-}CH_3COO$

B. CH_3COO^{-}

C. $C_2H_3O_2^{-}$

D. $^{-}C_2H_3O_2$

20. Sulfur dioxide emissions from coal-fired power plants is a source of acid deposition. Which are pre-combustion methods of reducing sulfur dioxide emissions?

I. Wash flue gases with crushed limestone and water.

II. Crush and wash the coal.

III. Crush and mix coal with a sulfur solvent, then wash.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

21. In which compound does vanadium have an oxidation state of +4?

A. $V(NO_3)_2$

B. $V(SO_4)_2$

C. $V_3(PO_4)_5$

D. $V_3(PO_4)_2$

22. The acid H_2S reacts with an active metal, M. Which combination shows the correct role of H_2S, and product formed from the reaction?

	Role of H_2S	**Product from H_2S reaction**
A.	Oxidizing agent	$H_2(g)$
B.	Oxidizing agent	$S(s)$
C.	Reducing agent	$H_2(g)$
D.	Reducing agent	$S(s)$

23. What occurs during the operation of the voltaic cell Cu | Cu^{2+} || Ag^{+} | Ag?

I. The blue colour of the $Cu^{2+}(aq)$ solution will fade.

II. $NO_3^{-}(aq)$ ions in the salt bridge will migrate toward the copper electrode.

III. The mass of the silver electrode will increase.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

24. Which species will most readily react with propane?

A. Br atom

B. Br_2 molecule

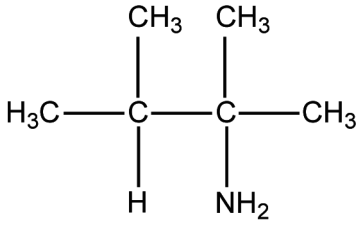
C. Br^{-} ion

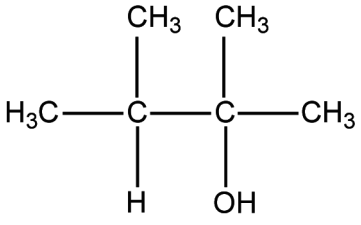
D. Br^{+} ion

25. Which pair of compounds are structural isomers?

	1st compound	**2nd compound**
A.	NH_2CH_2COOH	$NH_2CH_2OCH_3$
B.	CH_3CH_2OH	CH_3COCH_3
C.	CH_3CH_2OH	CH_3OCH_3
D.	NH_2CH_2COOH	$NH_2CH_2CH_2COOH$

26. What is the correct classification for the two compounds given?





	Type of amine	Type of alcohol
A.	Primary	Primary
B.	Tertiary	Tertiary
C.	Tertiary	Primary
D.	Primary	Tertiary

27. Which is the first product of distillation from the reaction of propan-1-ol with acidified potassium dichromate (VI)?

A. CH_3COCH_3

B. $CH_3CH_2CH_2OH$

C. CH_3CH_2CHO

D. CH_3CH_2COOH

28. Which procedure is most likely to produce a systematic error in determining the original concentration of NaOH (aq) by titration with HCl (aq)?

A. Repeating the titration only once instead of five times

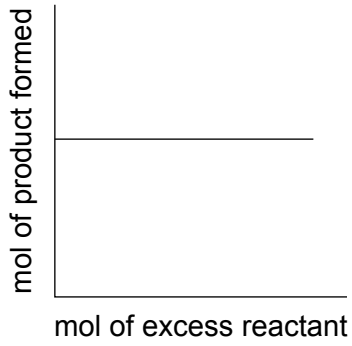
B. Using various burettes for each trial instead of the same one

C. Using a varying number of drops of the indicator for the titrations

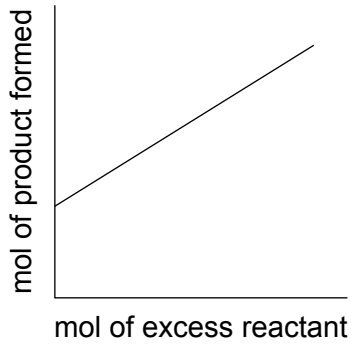
D. Titrating the sample two days after preparing it instead of on the day it was prepared

29. Which graph shows the relationship between quantity of product formed and quantity of excess reactant after the limiting reactant is consumed?

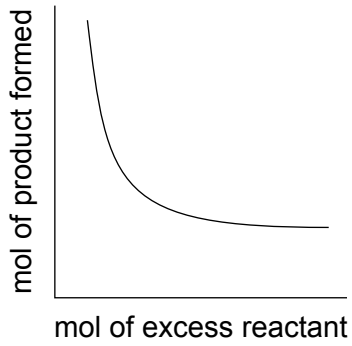
A.



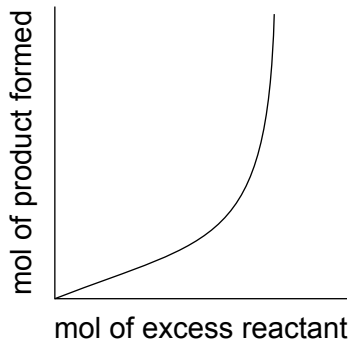
B.



C.



D.



30. Which type of data can be used to determine an empirical formula?

A. Percentage composition

B. Enthalpy of combustion

C. ^{1}H NMR

D. Infrared spectroscopy (IR)