Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 18 May 2022 (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]**.

2222 – 6110

13 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)

2222–6110

1. 0.2 mol of sodium hydrogencarbonate is decomposed by heating until constant mass.

$$2\ NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

How many moles of gas are produced?

A. 0.1

B. 0.2

C. 0.3

D. 0.4

2. Which sample contains the fewest moles of HCl?

$N_A = 6.02 \times 10^{23}\,mol^{-1}$.

Molar volume of an ideal gas at STP = $22.7\,dm^3\,mol^{-1}$.

A. $10.0\,cm^3$ of $0.1\,mol\,dm^{-3}$ HCl (aq)

B. 6.02×10^{24} molecules of HCl (g)

C. 0.365 g of HCl (g)

D. $2.27\,dm^3$ of HCl (g) at STP

3. What is the molecular formula of a compound with an empirical formula of CHO_2 and a relative molecular mass of 90?

A. CHO_2

B. $C_2H_2O_4$

C. $C_3H_6O_3$

D. $C_4H_{10}O_2$

4. 8.8 g of an oxide of nitrogen contains 3.2 g of oxygen. What is the empirical formula of the compound?

A. N_2O_5

B. N_2O

C. NO_2

D. NO

5. Naturally occurring gallium consists of the isotopes ^{71}Ga and ^{69}Ga. What is the approximate percentage abundance of ^{69}Ga?

$M_r(\text{Ga}) = 69.72$.

A. 40 %

B. 50 %

C. 60 %

D. 75 %

6. What is the maximum number of electrons that can occupy a p-orbital?

A. 2

B. 3

C. 6

D. 8

7. Which gases are acidic?

I. nitrogen dioxide
II. carbon dioxide
III. sulfur dioxide

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which of the following is the electron configuration of a metallic element?

A. [Ne] $3s^2\ 3p^2$

B. [Ne] $3s^2\ 3p^4$

C. [Ne] $3s^2\ 3p^6\ 3d^3\ 4s^2$

D. [Ne] $3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$

9. A compound consists of the ions Ca^{2+} and PO_4^{3-}. What are the name and formula of the compound?

	Name	Formula
A.	calcium phosphorus oxide	$CaPO_4$
B.	calcium phosphorus oxide	$Ca_3(PO_4)_2$
C.	calcium phosphate	$CaPO_4$
D.	calcium phosphate	$Ca_3(PO_4)_2$

10. What is the explanation for the high melting point of sodium chloride?

A. The covalent bond between sodium and chlorine atoms is strong.

B. Electrostatic attraction between sodium and chloride ions is strong.

C. Intermolecular forces in sodium chloride are strong.

D. Delocalized electrons cause strong bonding in sodium chloride.

11. Which molecule is most polar?

A. CF_4

B. CCl_4

C. CHF_3

D. $CClF_3$

12. For which species can resonance structures be drawn?

A. HCOOH

B. $HCOO^-$

C. CH_3OH

D. H_2CO_3

13. The energy from burning 0.250 g of ethanol causes the temperature of 150 cm^3 of water to rise by 10.5 °C. What is the enthalpy of combustion of ethanol, in kJ mol^{-1}?

Specific heat capacity of water: 4.18 $J g^{-1} K^{-1}$.

A. $\dfrac{150 \times 4.18 \times 10.5}{\dfrac{0.250}{46.08}}$

B. $\dfrac{150 \times 4.18 \times 10.5}{\dfrac{0.250}{46.08} \times 1000}$

C. $\dfrac{150 \times 4.18 \times (273 + 10.5)}{\dfrac{0.250}{46.08}}$

D. $\dfrac{150 \times 4.18 \times (273 + 10.5)}{\dfrac{0.250}{46.08} \times 1000}$

14. What is the enthalpy change of the following reaction?

$$CH_2CHCH_2CH_3 + HBr \rightarrow CH_3CHBrCH_2CH_3$$

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_2CHCH_2CH_3$	0.1
HBr	–36.3
$CH_3CHBrCH_2CH_3$	–156.0

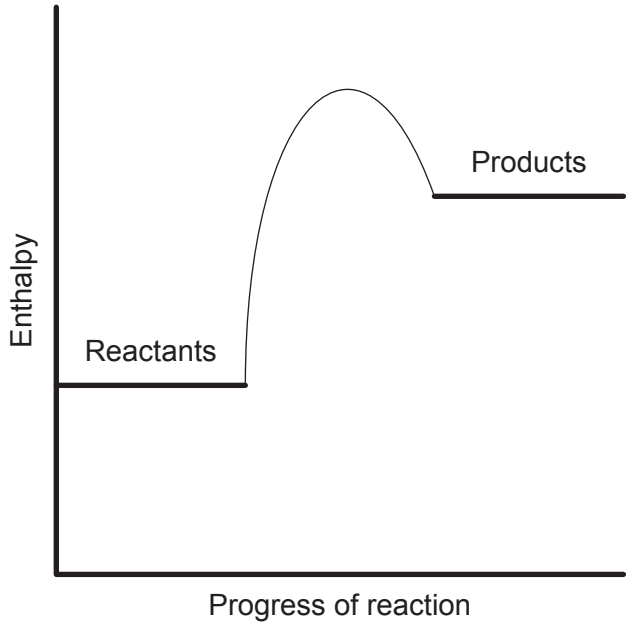
A. –119.6 kJ

B. +119.6 kJ

C. –119.8 kJ

D. +119.8 kJ

15. What is the correct interpretation of the following potential energy profile?



A. Endothermic reaction; products more stable than reactants.

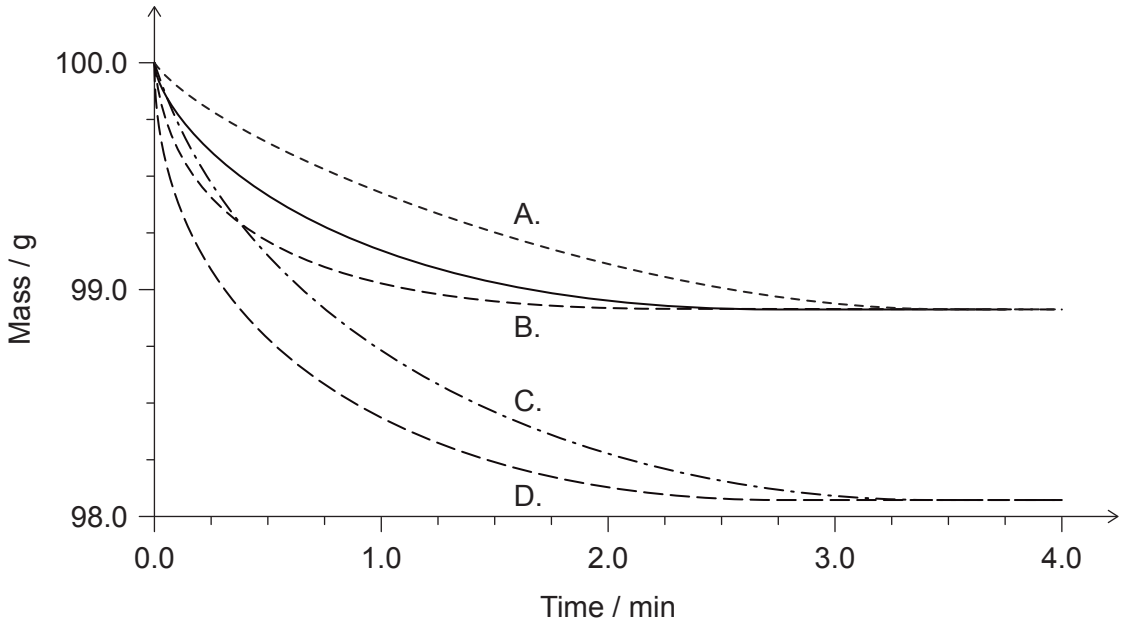
B. Exothermic reaction; products more stable than reactants.

C. Endothermic reaction; products less stable than reactants.

D. Exothermic reaction; products less stable than reactants.

16. A sample of calcium carbonate reacts with excess hydrochloric acid in a beaker. The solid line shows how the mass of the beaker changes with time.

Which dashed line represents the results obtained when the acid concentration is doubled?



17. A student was investigating rates of reaction. In which of the following cases would a colorimeter show a change in absorbance?

A. $KBr(aq) + Cl_2(aq)$

B. $Cu(s) + Na_2SO_4(aq)$

C. $HCl(aq) + NaOH(aq)$

D. $(CH_3)_3COH(aq) + K_2Cr_2O_7(aq)$

18. $\frac{1}{2}\ Cl_2(g) + \frac{1}{2}\ I_2(g) \rightleftharpoons ICl(g) \quad K_c = 454$

What is the K_c value for the reaction below?

$$2\ ICl(g) \rightleftharpoons Cl_2(g) + I_2(g)$$

A. 2×454

B. $\frac{1}{2 \times 454}$

C. 454^2

D. $\frac{1}{454^2}$

19. Which species are acids in the equilibrium below?

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

A. CH_3NH_2 and H_2O

B. H_2O and $CH_3NH_3^+$

C. H_2O and OH^-

D. CH_3NH_2 and $CH_3NH_3^+$

20. Which 0.01 mol dm^{-3} aqueous solution has the highest pH?

A. HCl

B. H_2SO_4

C. NaOH

D. NH_3

21. In which of the following species would sulfur be reduced if converted to SCl_2?

A. $S_2O_3^{2-}$

B. H_2S

C. S

D. SO_2

22. Which statement is correct for both voltaic and electrolytic cells?

A. The oxidation reaction releases electrons.

B. The oxidation reaction occurs at the positive electrode.

C. The cathode is negative.

D. Electrons flow through the electrolyte.

23. How many electrons are needed when the following half-equation is balanced using the lowest possible whole numbers?

$$\_\_\ NO_3^-(aq) + \_\_\ H^+(aq) + \_\_\ e^- \rightarrow \_\_\ NO(g) + \_\_\ H_2O(l)$$

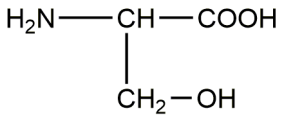
A. 1

B. 2

C. 3

D. 5

24. Which functional groups are present in serine?



A. nitro, carbonyl and carboxyl

B. amino, hydroxyl and carbonyl

C. nitro, carboxyl and hydroxyl

D. amino, carboxyl and hydroxyl

25. Which compounds are members of the same homologous series?

A. propanal, propanone, propanoic acid

B. propane, propene, propyne

C. hexan-1-ol, hexan-2-ol, hexan-3-ol

D. ethanol, propan-1-ol, butan-1-ol

26. Which reagents and conditions are best for converting propan-1-ol into propanoic acid?

A. Reflux with acidified potassium dichromate (VI)

B. Reflux with aqueous sodium hydroxide

C. Distil with acidified potassium dichromate (VI)

D. Distil with aqueous sodium hydroxide

27. What is produced when chlorobutane is treated with aqueous sodium hydroxide solution?

A. butane

B. butanoic acid

C. butanal

D. butan-1-ol

28. A student performed an experiment to find the melting point of sulfur, obtaining 118.0 °C. The literature value is 115.2 °C. What was the percentage error?

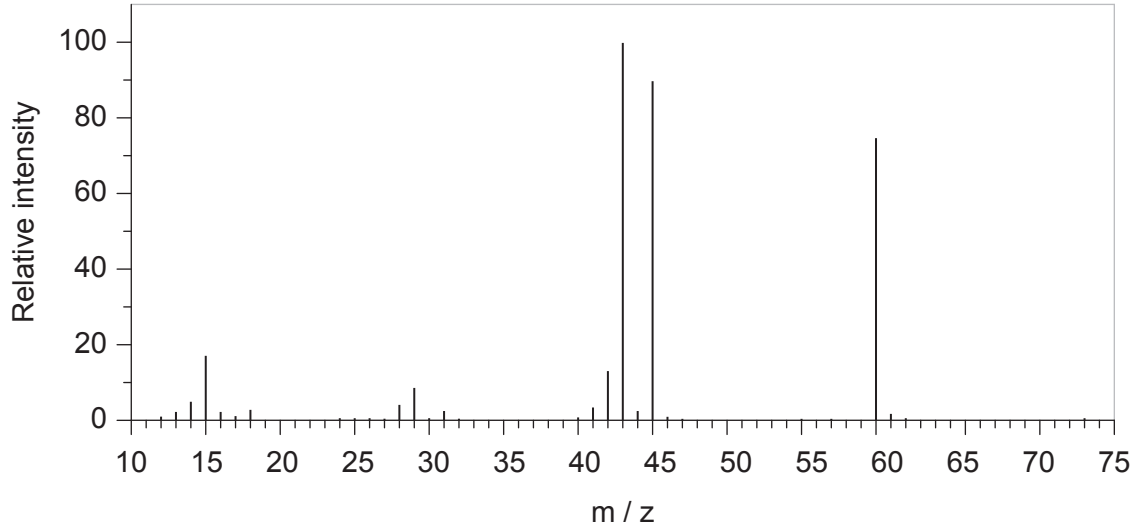
A. $\frac{118.0 - 115.2}{115.2} \times 100\,\%$

B. $\frac{115.2}{118.0} \times 100\,\%$

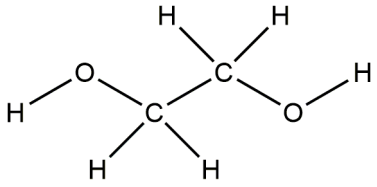
C. $\frac{118.0 - 115.2}{118.0} \times 100\,\%$

D. $\frac{118.0}{115.2} \times 100\,\%$

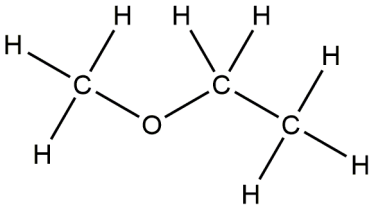
29. Which compound produces this mass spectrum?



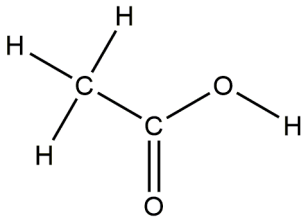
A.



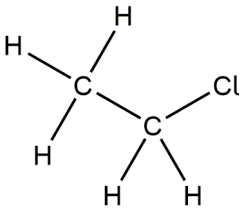
B.



C.

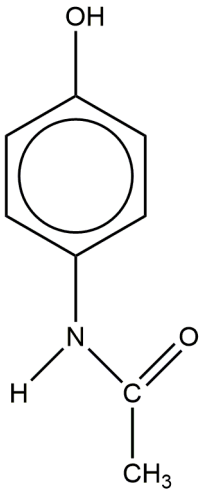


D.



30. What is the index of hydrogen deficiency (IHD) of this molecule?

Paracetamol (acetaminophen)



A. 3

B. 4

C. 5

D. 6

References:

29. Spectral Database for Organic Compounds, SDBS. SDBS Compounds and Spectral Search. [graph] Available at: https://sdbs.db.aist.go.jp [Accessed 3 January 2019].