Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Friday 14 May 2021 (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]**.

2221 – 6110

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 contains the most atoms of oxygen?

A. 64 g of O_2

B. 1.2×10^{24} molecules of O_2

C. 64 g of $C_3H_5O_3$

D. 1.2×10^{24} molecules of $C_3H_5O_3$

2. What is the resulting concentration, in $mol\,dm^{-3}$, when 1.0 cm^3 of 0.500 $mol\,dm^{-3}$ nitric acid solution is diluted to 50.0 cm^3 with water?

A. 0.002

B. 0.01

C. 0.04

D. 0.1

3. What volume of oxygen, in dm^3 at STP, is needed when 5.8 g of butane undergoes complete combustion?

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

A. $2 \times \frac{5.8}{12.01 \times 4 + 1.01 \times 10} \times 13 \times 22.7$

B. $\frac{5.8}{12.01 \times 4 + 1.01 \times 10} \times \frac{13}{2} \times 22.7$

C. $\frac{5.8}{12.01 \times 4 + 1.01 \times 10} \times \frac{2}{13} \times 22.7$

D. $\frac{5.8}{12.01 \times 4 + 1.01 \times 10} \times \frac{13}{2} \times \frac{22.7}{1000}$

4. What is the coefficient of HCl (aq) when the equation is balanced using the smallest possible whole numbers?

$$\_\_CuO(s) + \_\_HCl(aq) \rightarrow \_\_CuCl_2(aq) + \_\_H_2O(l)$$

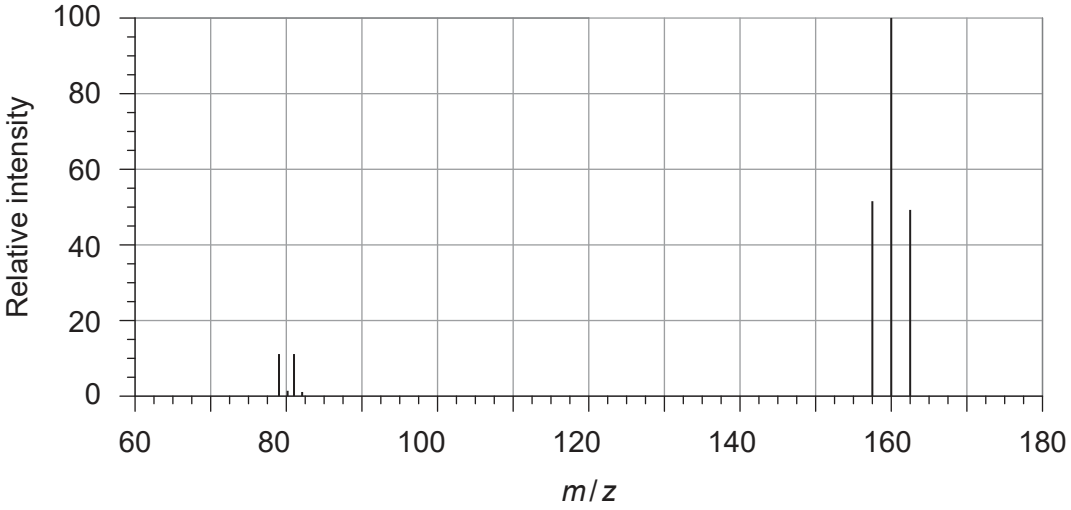
A. 1

B. 2

C. 3

D. 4

5. What is the relative molecular mass of bromine, according to the following mass spectrum?



A. $\dfrac{158 \times 52 + 160 \times 100 + 162 \times 48}{52 + 100 + 48}$

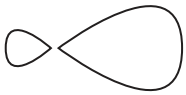
B. $\dfrac{158 \times 52 + 160 \times 100 + 162 \times 48}{158 + 160 + 162}$

C. $\dfrac{79 \times 11 + 81 \times 11 + 158 \times 52 + 160 \times 100 + 162 \times 48}{11 + 11 + 52 + 100 + 48}$

D. $\dfrac{79 \times 11 + 81 \times 11}{11 + 11}$

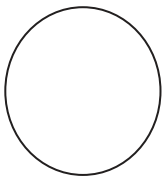
6. Which represents a *p* orbital?

A.

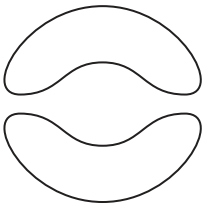


C.

B.



D.



7. Which species has the same electron configuration as argon?

A. Br^-

B. Ca^{2+}

C. Al^{3+}

D. Si^{4+}

8. Which trend is correct, going down group 1?

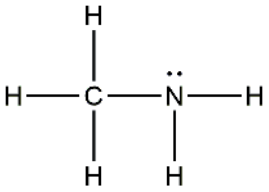
A. Melting point increases

B. Reactivity decreases

C. First ionisation energy increases

D. Electronegativity decreases

9. The Lewis structure of methylamine is shown.



What is the molecular geometry around N?

A. Square planar

B. Tetrahedral

C. Trigonal planar

D. Trigonal pyramidal

10. Which compound contains both ionic and covalent bonds?

A. MgO

B. CH_2Cl_2

C. CH_3COOH

D. NaOH

11. Which substance is most likely to be ionic?

	Melting point	Solubility in hexane	Electrical conductivity of solid
A.	High	Low	High
B.	Low	Low	Low
C.	Low	High	Low
D.	High	Low	Low

12. Along which series is the bond angle increasing?

A. NH_3 H_2O CH_4

B. CH_4 NH_3 H_2O

C. H_2O NH_3 CH_4

D. H_2O CH_4 NH_3

13. When sodium carbonate powder is added to ethanoic acid, the beaker becomes cooler.

Possible enthalpy diagrams are shown.

Diagram 1

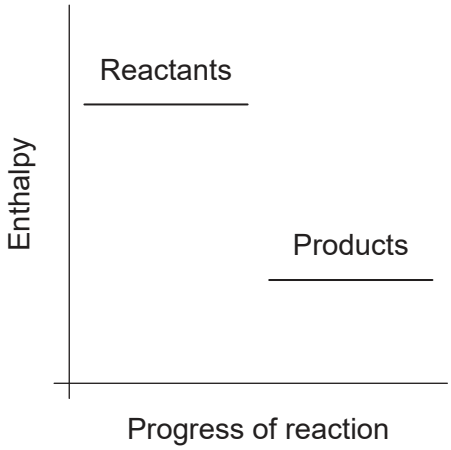
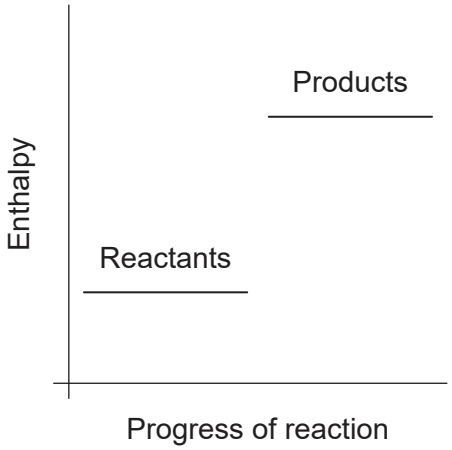


Diagram 2



Which correctly describes the reaction?

	Enthalpy diagram	Reaction
A.	1	Endothermic
B.	1	Exothermic
C.	2	Endothermic
D.	2	Exothermic

14. What is the enthalpy change, **in J**, when 5 g of water is heated from 10°C to 18°C?

Specific heat capacity of water: $4.18\,kJ\,kg^{-1}\,K^{-1}$

A. $5 \times 4.18 \times 8$

B. $5 \times 10^{-3} \times 4.18 \times 8$

C. $5 \times 4.18 \times (273 + 8)$

D. $5 \times 10^{-3} \times 4.18 \times (273 + 8)$

15. What is the enthalpy change of the reaction, in kJ?

$$2C\,(graphite) + O_2(g) \rightarrow 2CO\,(g)$$

Substance	$\Delta H^{\ominus}_{combustion}$ **/ kJ mol^{-1}**
C (graphite)	–394
CO (g)	–283

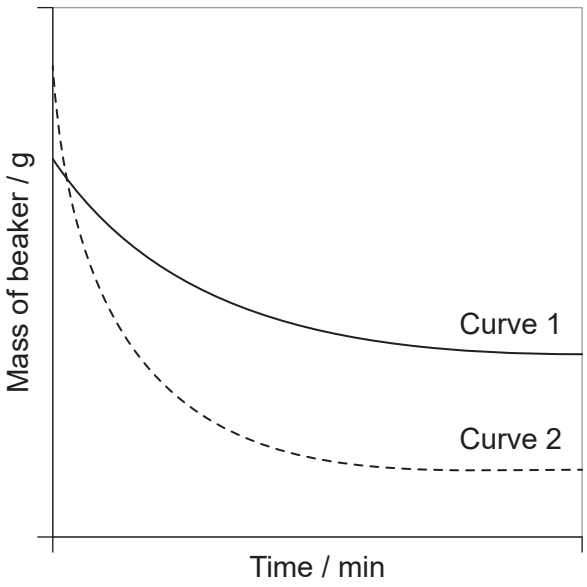
A. $-394 - 283$

B. $2\,(-394) + 2\,(-283)$

C. $-394 + 283$

D. $2\,(-394) + 2\,(283)$

16. Curve 1 shows the mass change when marble chips are added to excess hydrochloric acid in an open beaker.



Which changes would produce curve 2?

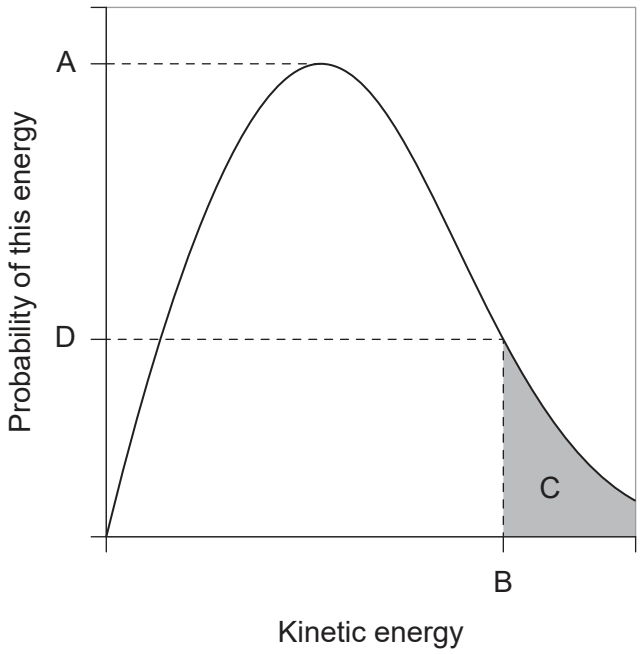
A. Powdering the marble chips and heating

B. Powdering the marble chips and doubling their mass

C. Doubling the volume of acid and heating

D. Doubling the acid concentration and powdering the marble chips

17. On the following Maxwell-Boltzmann distribution, which letter represents activation energy?



A. A

B. B

C. C

D. D

18. Which changes produce the greatest increase in the percentage conversion of methane?

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

	Pressure	**Proportion of $H_2O(g)$**
A.	Doubled	Halved
B.	Doubled	Doubled
C.	Halved	Doubled
D.	Halved	Halved

19. Which is amphiprotic?

A. NH_4^+

B. PO_4^{3-}

C. H_2O

D. H_3O^+

20. Which solution has a pH of 9?

A. $1.0 \times 10^{-9}\,mol\,dm^{-3}\,HCl\,(aq)$

B. $1.0 \times 10^{-5}\,mol\,dm^{-3}\,KOH\,(aq)$

C. $1.0 \times 10^{-9}\,mol\,dm^{-3}\,KOH\,(aq)$

D. $1.0 \times 10^{-5}\,mol\,dm^{-3}\,HCl\,(aq)$

21. A student performed displacement reactions using metals W and X and solutions of salts of metals W, X, Y and Z. The results are summarized in the table.

		Salt solution			
		W^{2+}	X^{2+}	Y^{2+}	Z^{2+}
Metal	W		No reaction	No reaction	No reaction
	X	Reaction		Reaction	No reaction

Which of the four metals is most reactive?

A. W

B. X

C. Y

D. Z

22. What is correct for this redox reaction?

$$MnO_2(s) + 2I^-(aq) + 4H^+(aq) \rightarrow Mn^{2+}(aq) + I_2(aq) + 2H_2O(l)$$

	Reduced	Reducing agent
A.	$MnO_2(s)$	$I^-(aq)$
B.	$I^-(aq)$	$H^+(aq)$
C.	$I^-(aq)$	$MnO_2(s)$
D.	$H^+(aq)$	$I^-(aq)$

23. Which statements are correct for electrolysis?

I. An exothermic reaction occurs.

II. Oxidation occurs at the anode (positive electrode).

III. The reaction is non-spontaneous.

A. I and II only

B. I and III only

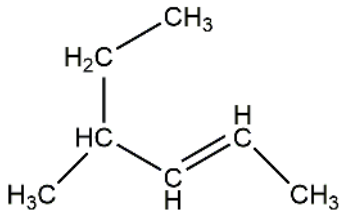
C. II and III only

D. I, II and III

24. Which series is in order of increasing boiling point?

A.	$CH_2CH_2CH_3OH$	CH_3COCH_3	$CH_3CH_2CH_3$
B.	$CH_3CH_2CH_3$	CH_3COCH_3	$CH_2CH_2CH_3OH$
C.	CH_3COCH_3	$CH_2CH_2CH_3OH$	$CH_3CH_2CH_3$
D.	$CH_3CH_2CH_3$	$CH_2CH_2CH_3OH$	CH_3COCH_3

25. What is the name of this compound, applying IUPAC rules?



A. 4-methylhex-2-ene

B. 4-ethylpent-2-ene

C. 2-ethylpent-3-ene

D. 3-methylhex-4-ene

26. What is formed in a propagation step of the substitution reaction between bromine and ethane?

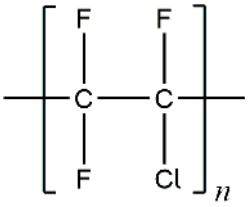
A. $CH_3CH_2\bullet$

B. $CH_3CH_2CH_2CH_3$

C. $H\bullet$

D. Br^-

27. Which monomer would produce the polymer shown?



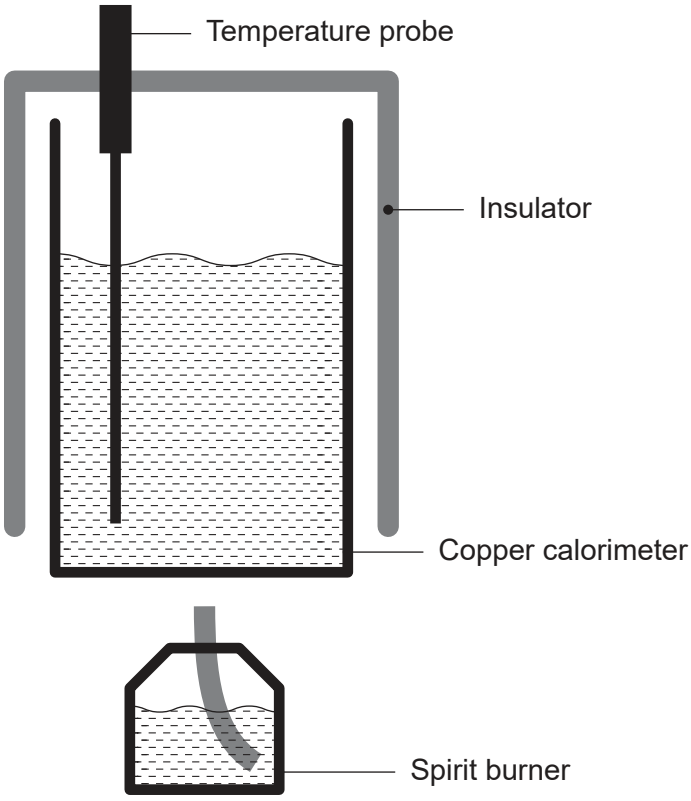
A. CF_3CCl_2F

B. CF_3CClHF

C. CF_2CClF

D. CF_2CF_2

28. The enthalpy of combustion of a fuel was determined using the calorimeter shown. The final result was lower than the literature value.



Which factors could have contributed to this error?

I. Not all heat from the combustion was transferred to the calorimeter.

II. Incomplete combustion occurred.

III. The temperature probe touched the bottom of the calorimeter.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. Burette readings for a titration are shown.

Burette readings / $cm^3 \pm 0.05\,cm^3$	**Trial 1**	**Trial 2**	**Trial 3**
Final	11.35	24.60	11.70
Initial	0.20	13.50	0.50

What is the mean titre?

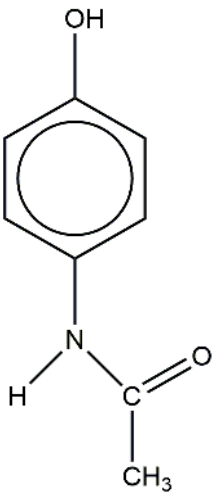
A. $11.1\,cm^3 \pm 0.1\,cm^3$

B. $11.15\,cm^3 \pm 0.05\,cm^3$

C. $11.2\,cm^3 \pm 0.05\,cm^3$

D. $11.2\,cm^3 \pm 0.1\,cm^3$

30. Determine the index of hydrogen deficiency (IHD) of paracetamol.



A. 3

B. 4

C. 5

D. 6

References:

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