Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Thursday 14 May 2015 (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]**.

2215 – 6116

The Periodic Table

1	2											3	4	5	6	7	0
1 **H** 1.01																	2 **He** 4.00
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
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															

Atomic number

Element

Relative atomic mass

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. What is the total number of protons and electrons in one mole of hydrogen gas?

A. 2

B. 4

C. 1.2×10^{24}

D. 2.4×10^{24}

2. A hydrocarbon contains 85.7 % carbon by mass. What is the empirical formula of the hydrocarbon?

A. C_2H_3

B. CH_2

C. C_2H_5

D. CH_3

3. What is the sum of all coefficients for the combustion of one mole of propane?

$$\_\_\_ C_3H_8(g) + \_\_\_ O_2(g) \rightarrow \_\_\_ CO_2(g) + \_\_\_ H_2O(l)$$

A. 8

B. 12

C. 13

D. 15

4. A gas with a molar mass (M) of $44\,\text{g mol}^{-1}$ occupies a volume of $2.00 \times 10^3\,\text{cm}^3$ at a pressure of $1.01 \times 10^5\,\text{Pa}$ and a temperature of $25\,^\circ\text{C}$. Which expression is correct for the calculation of the mass of the gas, in g? ($R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$)

A. $\dfrac{44 \times 1.01 \times 10^5 \times 2.00 \times 10^{-3}}{8.31 \times 298}$

B. $\dfrac{44 \times 1.01 \times 10^5 \times 2.00 \times 10^{3}}{8.31 \times 25}$

C. $\dfrac{1.01 \times 10^5 \times 2.00 \times 10^{-3}}{44 \times 8.31 \times 298}$

D. $\dfrac{44 \times 1.01 \times 10^5 \times 2.00 \times 10^{3}}{8.31 \times 298}$

5. Which statement is correct for the ion $^{9}_{4}\text{Be}^{2+}$?

A. The ion contains 15 subatomic particles in the nucleus.

B. The ion contains more protons than neutrons in the nucleus.

C. The ion has an electron arrangement of 2,2.

D. Most of the total volume of the ion is empty space.

6. Which ion will be deflected most in a mass spectrometer?

A. $^{16}\text{O}^{+}$

B. $^{16}\text{O}^{2+}$

C. $^{18}\text{O}^{+}$

D. $^{18}\text{O}^{2+}$

7. Which statement is correct for the halogens (F $\rightarrow$ I)?

A. Electronegativity decreases from fluorine to iodine.

B. Atomic radius decreases from fluorine to iodine.

C. First ionization energy increases from fluorine to iodine.

D. Reactivity of the element with sodium increases from fluorine to iodine.

8. Which combination of properties best describes sodium oxide, Na_2O?

	Nature of bonding	Acidic or basic behaviour
A.	covalent	acidic
B.	ionic	basic
C.	covalent	basic
D.	ionic	acidic

9. The formula of gallium phosphate is $GaPO_4$. What is the correct formula of gallium sulfate?

A. $GaSO_4$

B. GaS

C. $Ga_2(SO_4)_3$

D. Ga_2S_3

10. Which species contain a dative covalent (coordination or coordinate) bond?

I. Carbon monoxide, CO

II. Ammonia, NH_3

III. Oxonium ion, H_3O^+

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. Which combination of shape and bond angle best describes a molecule of sulfur dioxide, SO_2?

	Shape	Bond angle
A.	linear	180°
B.	tetrahedral	105°
C.	bent (v-shaped)	119°
D.	trigonal planar	120°

12. Which statement is correct about carbon-oxygen bond lengths?

A. The C–O bond lengths are equal in propanoic acid, C_2H_5COOH.

B. The C–O bond length in carbon dioxide, CO_2, is longer than the C–O bond length in methanol, CH_3OH.

C. The C–O bond length in carbon dioxide, CO_2, is longer than the C–O bond length in carbon monoxide, CO.

D. The C–O bond lengths are equal in ethyl ethanoate, $CH_3COOC_2H_5$.

13. Which compound has hydrogen bonds between its molecules?

A. CH_3COCH_3

B. CH_3CHO

C. CH_3CH_2F

D. $CH_3CH_2NH_2$

14. Which combination is correct for the standard enthalpy change of neutralization?

	Process	Sign of $\Delta H^{\ominus}$
A.	exothermic	negative
B.	exothermic	positive
C.	endothermic	negative
D.	endothermic	positive

15. When four moles of aluminium and four moles of iron combine with oxygen to form their oxides, the enthalpy changes are –3338 kJ and –1644 kJ respectively.

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s) \qquad \Delta H = -3338\,kJ$$
$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \qquad \Delta H = -1644\,kJ$$

What is the enthalpy change, in kJ, for the reduction of one mole of iron(III) oxide by aluminium?

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$$

A. $+1694$

B. $+847$

C. -847

D. -1694

16. Which enthalpy changes can be calculated using **only** bond enthalpy data?

I. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

II. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

III. $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

17. Which is a correct unit for expressing the rate of a reaction?

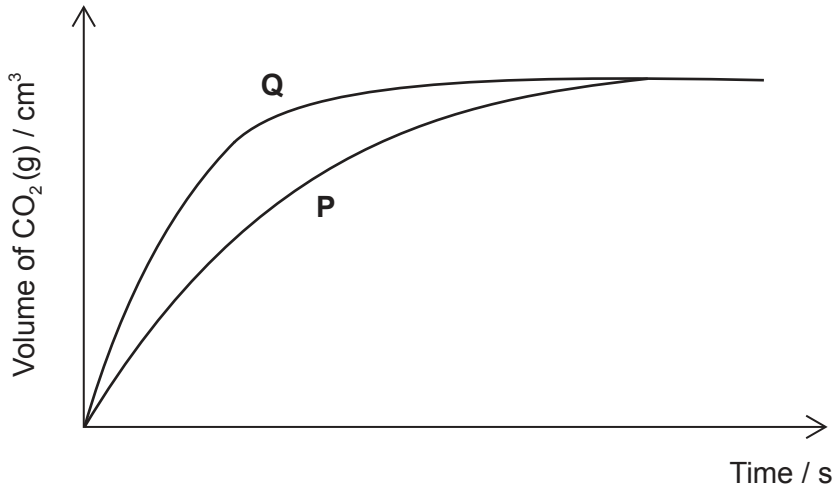
A. $mol\,dm^{-3}\,s^{-1}$

B. $mol\,dm^{-3}\,s$

C. $mol\,s$

D. $mol^{-1}\,dm^{3}\,s^{-1}$

18. 100 cm^3 of a 1.00 mol dm^{-3} solution of hydrochloric acid is added to 2.00 g of small pieces of calcium carbonate at 20 °C. The volume of carbon dioxide produced against time is plotted to give curve **P**.



Which change will produce curve **Q**, given that calcium carbonate is always the limiting reagent?

A. Increasing the volume of the hydrochloric acid to 200 cm^3

B. Increasing the mass of calcium carbonate to 4.00 g

C. Increasing the concentration of the hydrochloric acid to 2.00 mol dm^{-3}

D. Replacing the 2.00 g of small pieces of calcium carbonate with 2.00 g of larger pieces of calcium carbonate

19. What is the equilibrium constant expression, K_c, for the formation of hydrogen iodide from its elements?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

A. $K_c = \frac{[HI]^2}{[H_2] \times [I_2]}$

B. $K_c = \frac{[2HI]}{[H_2] + [I_2]}$

C. $K_c = \frac{2[HI]^2}{[H_2] + [I_2]}$

D. $K_c = \frac{[2HI]}{[H_2] \times [I_2]}$

20. Which combination of temperature and pressure will give the greatest yield of sulfur trioxide?

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196\,kJ$$

	Temperature	Pressure
A.	high	low
B.	low	high
C.	high	high
D.	low	low

21. Which species **cannot** function as a Lewis acid?

A. BF_3

B. $AlCl_3$

C. CCl_4

D. H^+

22. 10.0 cm^3 of a solution of a strong acid with a pH of 3 is added to a volumetric flask and the total volume is made up to 1.00 dm^3 by adding distilled water. The resulting solution is then thoroughly mixed.

What is the pH of the diluted solution?

A. 1

B. 2

C. 4

D. 5

23. What are the oxidation states of each element in K_2CrO_4?

	Potassium	Chromium	Oxygen
A.	+1	+6	−2
B.	−1	+6	−2
C.	+1	−6	+2
D.	−1	−6	+2

24. What is the coefficient for I^- when the following equation is balanced using the smallest possible whole numbers?

$$IO_3^-(aq) + \_\_\_ I^-(aq) + \_\_\_ H^+(aq) \rightarrow \_\_\_ I_2(aq) + \_\_\_ H_2O(l)$$

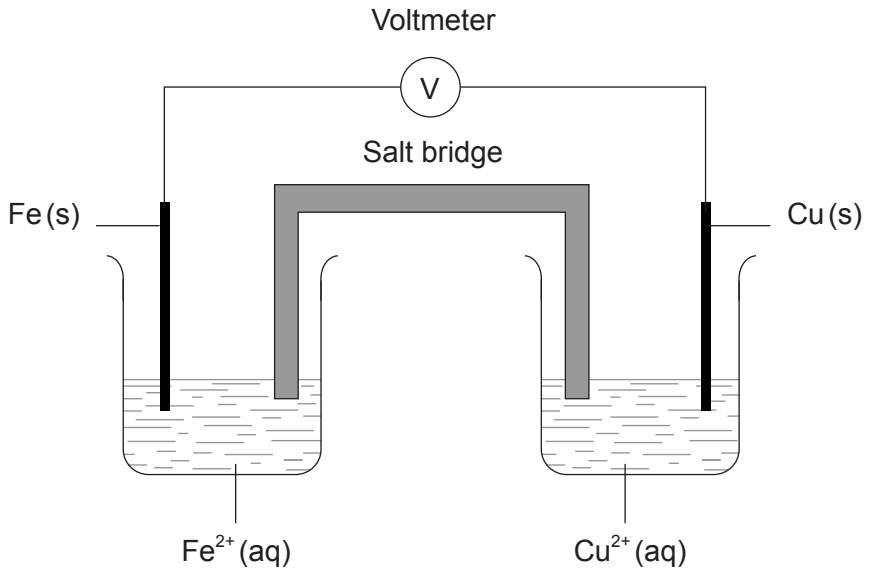
A. 1

B. 2

C. 3

D. 5

25. A voltaic cell is made by connecting a copper half-cell, $Cu(s)|Cu^{2+}(aq)$, to an iron half-cell $Fe(s)|Fe^{2+}(aq)$.



Which combination correctly identifies the positive electrode and the species being oxidized?

	Positive electrode	Species oxidized
A.	copper	iron
B.	copper	copper(II) ions
C.	iron	copper
D.	iron	copper(II) ions

26. Applying IUPAC rules, what is the name of $CH_3CH(CH_3)CH_2COOH$?

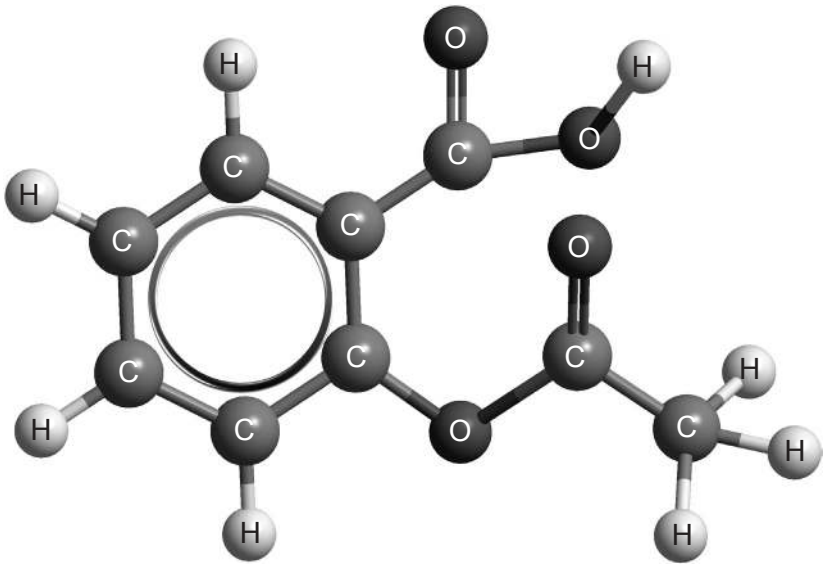
A. 2,3-dimethylpropanoic acid

B. Pentanoic acid

C. 3-methylbutanoic acid

D. 2-methylbutanoic acid

27. Which of the following functional groups are present in aspirin?



Aspirin

A. Hydroxyl (alcohol) and ester

B. Carboxyl (carboxylic acid) and ester

C. Carboxyl (carboxylic acid) and carbonyl (ketone)

D. Hydroxyl (alcohol) and carbonyl (ketone)

28. Which statements are correct for the reaction of ethene with bromine in the absence of ultraviolet light?

I. It is an addition reaction.

II. The organic product is colourless.

III. The organic product is saturated.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. Which combination best describes the substitution reaction between bromoethane and dilute aqueous sodium hydroxide?

$$CH_3CH_2Br + OH^- \rightarrow CH_3CH_2OH + Br^-$$

	Nucleophile	Mechanism
A.	OH^-	S_N1
B.	OH^-	S_N2
C.	CH_3CH_2Br	S_N1
D.	CH_3CH_2Br	S_N2

30. What is the best way to minimize the random uncertainty when titrating an acid of unknown strength against a standard solution of sodium hydroxide (*ie* one of known concentration)?

A. First standardize the sodium hydroxide solution against a standard solution of a different acid.

B. Use a pH meter rather than an indicator to determine the equivalence point.

C. Keep your eye at the same height as the meniscus when reading the burette.

D. Repeat the titration several times.