Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Monday 14 November 2016 (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]**.

13 pages

International Baccalaureate
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The Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
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
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
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)
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 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

Atomic number

Element

Relative atomic mass

†	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 change of state is exothermic?

　　A.　$CO_2(s) \rightarrow CO_2(g)$

　　B.　$H_2O(l) \rightarrow H_2O(g)$

　　C.　$NH_3(g) \rightarrow NH_3(l)$

　　D.　$Fe(s) \rightarrow Fe(l)$

2.　Which volume, in cm^3, of $0.20 \, mol \, dm^{-3}$ NaOH(aq) is needed to neutralize $0.050 \, mol$ of $H_2S(g)$?

$$H_2S(g) + 2NaOH(aq) \rightarrow Na_2S(aq) + 2H_2O(l)$$
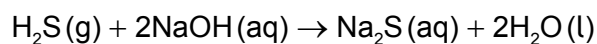
　　A.　0.25

　　B.　0.50

　　C.　250

　　D.　500

3.　The complete combustion of $15.0 \, cm^3$ of a gaseous hydrocarbon **X** produces $60.0 \, cm^3$ of carbon dioxide gas and $75.0 \, cm^3$ of water vapour. What is the molecular formula of **X**? (All volumes are measured at the same temperature and pressure.)

　　A.　C_4H_6

　　B.　C_4H_8

　　C.　C_4H_{10}

　　D.　C_6H_{10}

Turn over

4. 5.0 mol of Fe_2O_3 (s) and 6.0 mol of CO (g) react according to the equation below. What is the limiting reactant and how many moles of the excess reactant remain unreacted?

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$
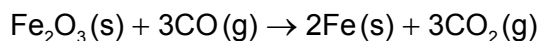
	Limiting reactant	Moles of excess reactant remaining
A.	CO	2.0
B.	CO	3.0
C.	Fe_2O_3	1.0
D.	Fe_2O_3	2.0

5. Which is correct for the line emission spectrum for hydrogen?

M   N   O   P Q R
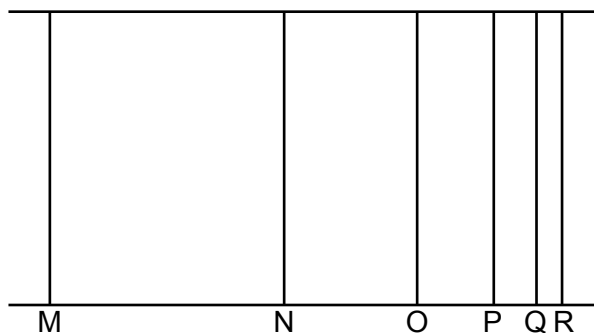
A. Line M has a higher energy than line N.

B. Line N has a lower frequency than line M.

C. Line M has a longer wavelength than line N.

D. Lines converge at lower energy.

6. What is the condensed electron configuration of the Fe^{2+} ion?

A. $[Ar]3d^6$

B. $[Ar]3d^4 4s^2$

C. $[Ar]3d^5 4s^1$

D. $[Ar]3d^6 4s^2$

7. Which equation represents the first electron affinity of chlorine?

A. $Cl(g) + e^- \rightarrow Cl^-(g)$

B. $\dfrac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

C. $Cl^+(g) + e^- \rightarrow Cl(g)$

D. $Cl(g) \rightarrow Cl^+(g) + e^-$

8. Which solution forms when phosphorus(V) oxide, P_4O_{10}, reacts with water?

	Product	pH of solution
A.	H_3PO_3	< 7
B.	H_3PO_3	> 7
C.	H_3PO_4	< 7
D.	H_3PO_4	> 7

9. Which pair of molecules has the same bond angles?

A. PCl_3 and BCl_3

B. SO_2 and CO_2

C. H_2O and NH_3

D. CCl_4 and SiH_4

**10.** The C=N bond has a bond length of 130 pm and an average bond enthalpy of 615 kJ mol^{-1}. Which values would be most likely for the C–N bond?

	Bond length / pm	Average bond enthalpy / kJ mol^{-1}
A.	147	286
B.	147	890
C.	116	286
D.	116	890

11. Between which pair of molecules can hydrogen bonding occur?

A. CH_4 and H_2O

B. CH_3OCH_3 and CF_4

C. CH_4 and HF

D. CH_3OH and H_2O

12. Which substance has a giant covalent structure?

	Melting point / °C	Solubility in water	Electrical conductivity in the molten state
A.	186	high	none
B.	801	high	good
C.	1083	low	good
D.	1710	low	none

13. Hydrazine reacts with oxygen.

$$N_2H_4\,(l) + O_2\,(g) \rightarrow N_2\,(g) + 2H_2O\,(l) \qquad \Delta H^\ominus = -623\,kJ$$
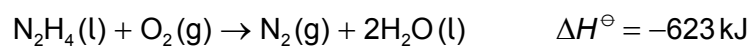
What is the standard enthalpy of formation of $N_2H_4\,(l)$ in kJ? The standard enthalpy of formation of $H_2O\,(l)$ is $-286\,kJ$.

A. $-623 - 286$

B. $-623 + 572$

C. $-572 + 623$

D. $-286 + 623$

14. In which reaction do the reactants have a lower potential energy than the products?

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

   B. $HBr(g) \rightarrow H(g) + Br(g)$

   C. $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

   D. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

15. $5.35\,g$ of solid ammonium chloride, $NH_4Cl(s)$, was added to water to form $25.0\,g$ of solution. The maximum decrease in temperature was $14\,K$. What is the enthalpy change, in $kJ\,mol^{-1}$, for this reaction? (Molar mass of $NH_4Cl = 53.5\,g\,mol^{-1}$; the specific heat capacity of the solution is $4.18\,J\,g^{-1}\,K^{-1}$)

   A. $\Delta H = + \dfrac{25.0 \times 4.18 \times (14 + 273)}{0.1 \times 1000}$

   B. $\Delta H = - \dfrac{25.0 \times 4.18 \times 14}{0.1 \times 1000}$

   C. $\Delta H = + \dfrac{25.0 \times 4.18 \times 14}{0.1 \times 1000}$

   D. $\Delta H = + \dfrac{25.0 \times 4.18 \times 14}{1000}$

16. For the reaction **R** → **P**, which letter represents the activation energy for the catalysed **reverse** reaction?


Energy

Extent of reaction
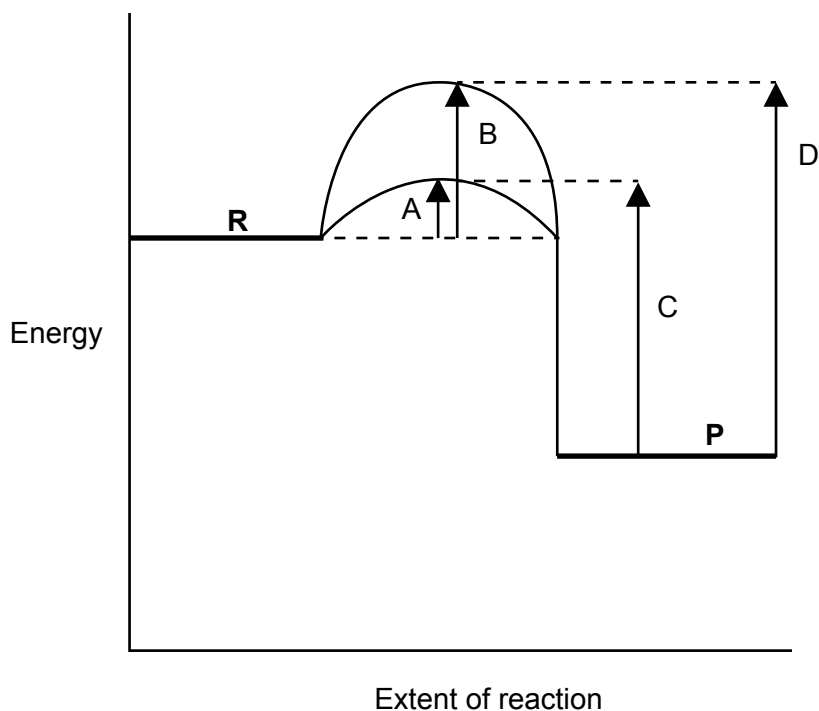
17. Which experimental methods could be used to observe the progress of the following reaction?

$$Cr_2O_7^{2-}(aq) + 6I^-(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 7H_2O(l)$$
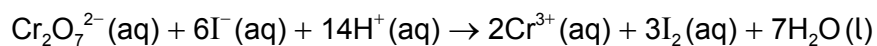
    I.   Change in colour
    II.   Change in mass
    III.   Change in electrical conductivity

    A.   I and II only

    B.   I and III only

    C.   II and III only

    D.   I, II and III

**18.** What happens when the temperature of the following equilibrium system is increased?

$$CO\,(g) + 2H_2\,(g) \rightleftharpoons CH_3OH\,(g) \qquad\qquad \Delta H^{\ominus} = -91\,kJ$$
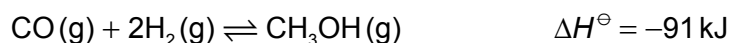
	Position of equilibrium	Reaction rates of forward and reverse reactions
A.	shifts to the left	increase
B.	shifts to the left	decrease
C.	shifts to the right	decrease
D.	shifts to the right	increase

**19.** Which species behave as Brønsted–Lowry bases in the following reaction?

$$H_2SO_4 + HNO_3 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$
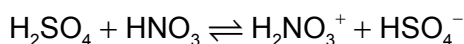
A. HNO_3 and HSO_4^-

B. HNO_3 and $H_2NO_3^+$

C. H_2SO_4 and HSO_4^-

D. $H_2NO_3^+$ and HSO_4^-

20. What occurs when solid sodium hydrogen carbonate reacts with aqueous sulfuric acid?

A.   Bubbles of sulfur dioxide form.

B.   Bubbles of both hydrogen and carbon dioxide form.

C.   Bubbles of hydrogen form.

D.   Bubbles of carbon dioxide form.

21. Which is a correct statement for the reaction below?

$$2MnO_4^-\,(aq) + 6H^+\,(aq) + 5NO_2^-\,(aq) \rightarrow 2Mn^{2+}\,(aq) + 5NO_3^-\,(aq) + 3H_2O\,(l)$$
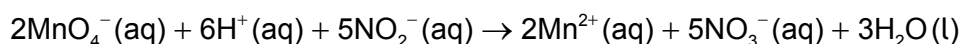
A. MnO_4^- is the reducing agent and the oxidation number of Mn increases.

B. MnO_4^- is the oxidizing agent and the oxidation number of Mn decreases.

C. NO_2^- is the reducing agent and the oxidation number of N decreases.

D. NO_2^- is the oxidizing agent and the oxidation number of N increases.

22. A voltaic cell is constructed from zinc and copper half-cells. Zinc is more reactive than copper.
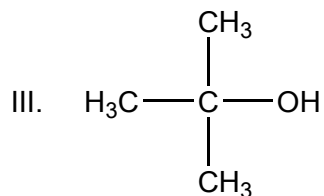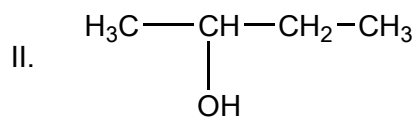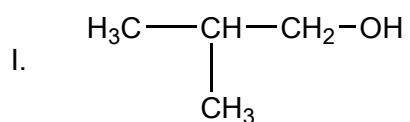Which statement is correct when this cell produces electricity?

Voltmeter

V

Salt bridge

Zn ———　　　　　　　　　　　　　　　　　——— Cu

Zn^{2+}(aq)　　　　　　　　　　　Cu^{2+}(aq)
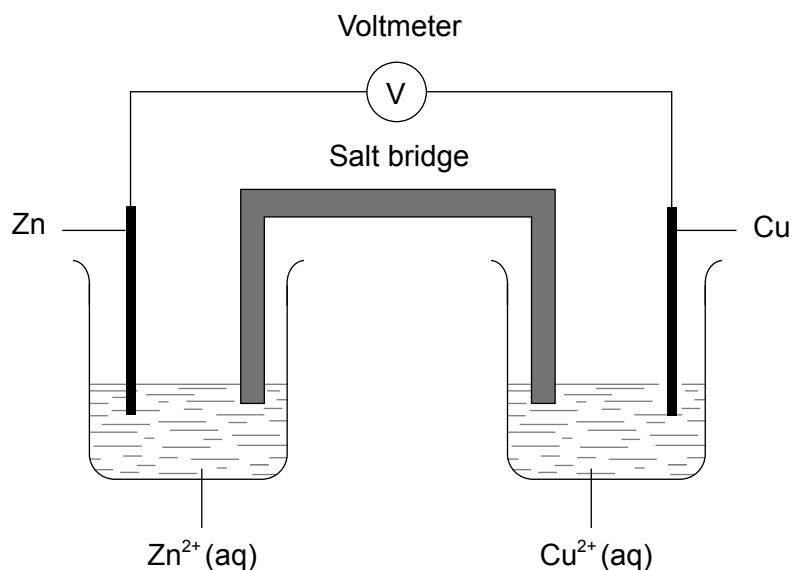
A.　Electrons flow from the copper half-cell to the zinc half-cell.

B.　The concentration of Cu^{2+}(aq) increases.

C.　Electrons flow through the salt bridge.

D.　Negative ions flow through the salt bridge from the copper half-cell to the zinc half-cell.

23. The structure of a drug used to treat symptoms of Alzheimer's disease is shown below.
Which functional groups are present in this molecule?

OH

O

CH_3O

N

CH_3
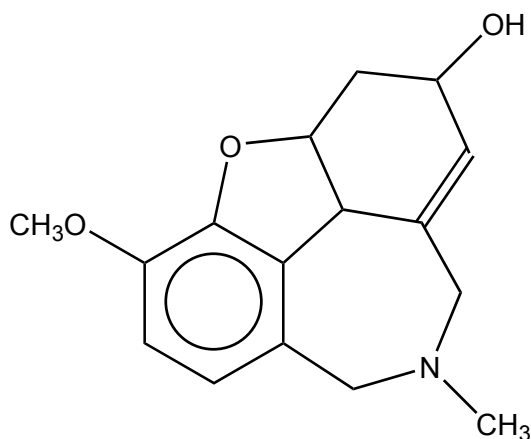
A.　Hydroxyl and ester

B.　Hydroxide and ether

C.　Hydroxyl and ether

D.　Hydroxide and ester

24. Which alcohols are oxidized by acidified potassium dichromate(VI) solution when heated?

I. H_3C—CH—CH_2—OH
            |
           CH_3

II. H_3C—CH—CH_2—CH_3
            |
           OH

III. H_3C—C—OH (with CH_3 above and CH_3 below the central C)

A.   I and II only

B.   I and III only

C.   II and III only

D.   I, II and III

25. Which monomer is used to form the polymer with the following repeating unit?

$$\left[\begin{array}{c} H \quad\quad H \\ | \quad\quad | \\ C—C \\ | \quad\quad | \\ CH_3 \quad CH_3 \end{array}\right]$$
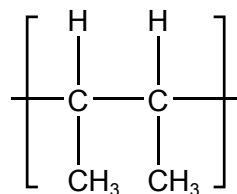
A. $CH_3CH{=}CHCH_3$

B. $CH_3CH_2CH{=}CH_2$

C. $CH_3CH_2CH_2CH_3$

D. $(CH_3)_2C{=}CH_2$

Turn over

26. Which type of reaction occurs when methanol and propanoic acid react together in the presence of a catalyst?

    A.   Addition

    B.   Condensation

    C.   Redox

    D.   Neutralization

27. A student carried out a titration to determine the concentration of an acid and found that his value had good precision but poor accuracy. Which process explains this outcome?

    A.   Consistently overshooting the volume of solution from the burette into the flask.

    B.   Collection of insufficient titration data.

    C.   Reading the meniscus in the burette at a different angle each time.

    D.   Forgetting to rinse the flask after one of the titrations.

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

    A.   3

    B.   4

    C.   5
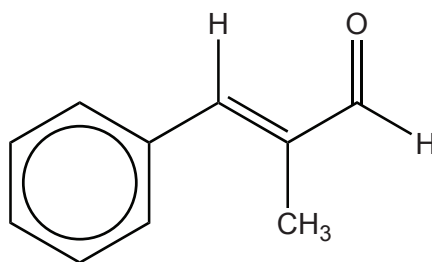
    D.   6

29. What is always correct about the molecular ion, M^+, in a mass spectrum of a compound?

    A.   The M^+ ion peak has the smallest m/z ratio in the mass spectrum.

    B.   The m/z ratio of the M^+ ion peak gives the relative molecular mass of the molecule.

    C.   The M^+ ion is the most stable fragment formed during electron bombardment.

    D.   The M^+ ion peak has the greatest intensity in the mass spectrum.

30. A student measured the change in mass on heating a sample of calcium carbonate, $CaCO_3$(s). What is the mass loss?

Mass before heating: $2.347\,g \pm 0.001$
Mass after heating: $2.001\,g \pm 0.001$

A. $0.346\,g \pm 0.001$

B. $0.346\,g \pm 0.002$

C. $0.35\,g \pm 0.002$

D. $0.35\,g \pm 0.001$