88106101

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

CHEMISTRY
HIGHER LEVEL
PAPER 1

Thursday 11 November 2010 (afternoon)

1 hour

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 Periodic Table

1	2											3	4	5	6	7	0
1 **H** 1.01				Atomic Number **Element** Atomic Mass													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)															

†	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. On analysis, a compound with molar mass 60 g mol^{-1} was found to contain 12 g of carbon, 2 g of hydrogen and 16 g of oxygen. What is the molecular formula of the compound?

A. CH_2O

B. CH_4O

C. C_2H_4O

D. $C_2H_4O_2$

2. 300 cm^3 of water is added to a solution of 200 cm^3 of 0.5 mol dm^{-3} sodium chloride. What is the concentration of sodium chloride in the new solution?

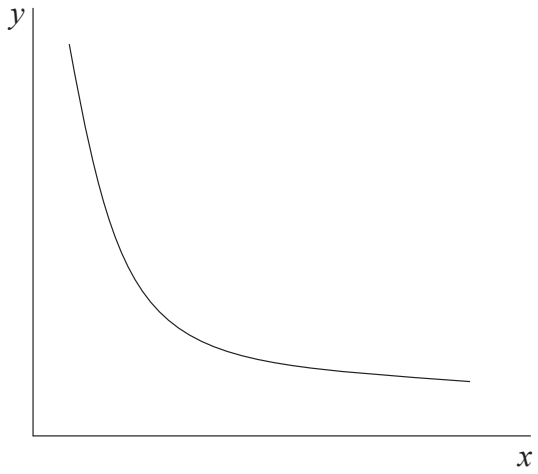
A. 0.05 mol dm^{-3}

B. 0.1 mol dm^{-3}

C. 0.2 mol dm^{-3}

D. 0.3 mol dm^{-3}

3. The graph below represents the relationship between two variables in a fixed amount of gas.



Which variables could be represented by each axis?

	***x*-axis**	***y*-axis**
A.	pressure	temperature
B.	volume	temperature
C.	pressure	volume
D.	temperature	volume

4. Which statement about the species $^{63}Cu^{2+}$ and $^{65}Cu^{+}$ is correct?

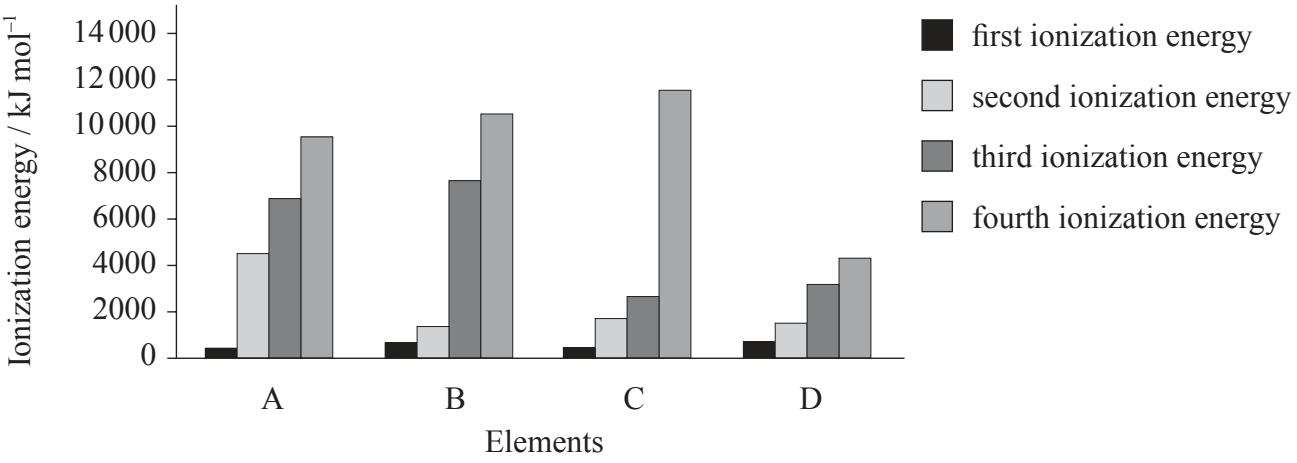
A. Both species have the same number of protons.

B. Both species have the same number of electrons.

C. Both species have the same number of neutrons.

D. Both species have the same electron arrangement.

5. The graph below shows the first four ionization energies of four elements A, B, C and D (the letters are not their chemical symbols). Which element is magnesium?



6. Which statements about the periodic table are correct?

I. The elements Mg, Ca and Sr have similar chemical properties.

II. Elements in the same period have the same number of main energy levels.

III. The oxides of Na, Mg and P are basic.

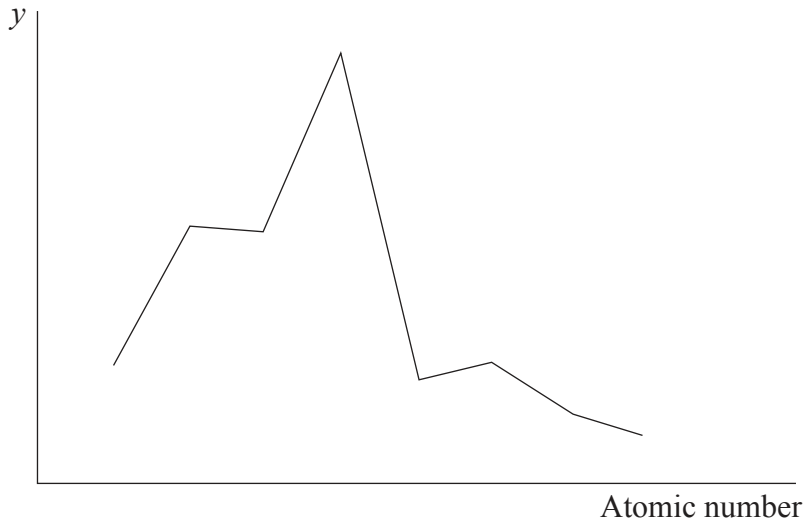
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. The *x*-axis of the graph below represents the atomic number of the elements in period 3.



Which variable could represent the *y*-axis?

A. Melting point

B. Electronegativity

C. Ionic radius

D. Atomic radius

8. In which complexes does iron have an oxidation number of +3?

I. $[Fe(H_2O)_6]^{3+}$

II. $[Fe(H_2O)_5(CN)]^{2+}$

III. $[Fe(CN)_6]^{3-}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. The electronegativities of four different elements are given below (the letters are not their chemical symbols).

Element	W	X	Y	Z
Electronegativity	0.9	1.2	3.4	4.0

Based on this information which statement is correct?

A. W is a non-metal.

B. W and X form an ionic compound.

C. Y is a metal.

D. Y and Z form a covalent compound.

10. Which species contain a dative covalent bond?

I. HCHO

II. CO

III. H_3O^+

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. Which substance is made up of a lattice of positive ions and free moving electrons?

A. Graphite

B. Sodium chloride

C. Sulfur

D. Sodium

12. Which molecule has an octahedral shape?

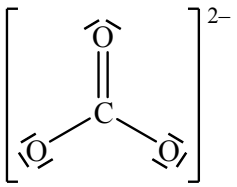
A. SF_6

B. PCl_5

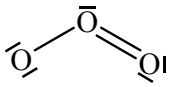
C. XeF_4

D. BF_3

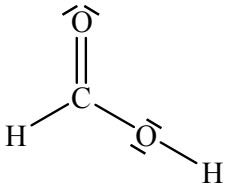
13. Which species have delocalized electrons?



I



II



III

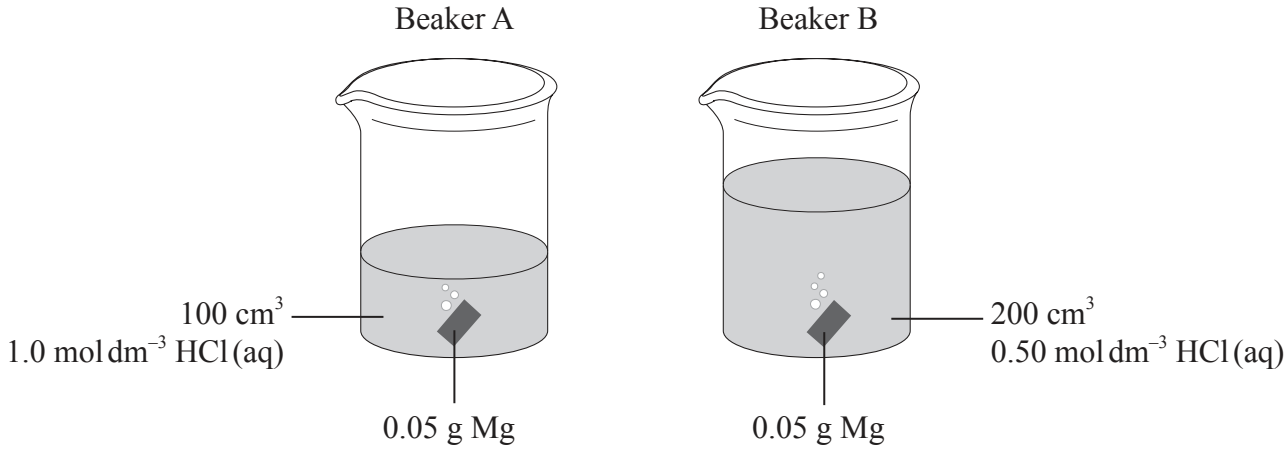
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. Identical pieces of magnesium are added to two beakers, A and B, containing hydrochloric acid. Both acids have the same initial temperature but their volumes and concentrations differ.



Which statement is correct?

A. The maximum temperature in A will be higher than in B.

B. The maximum temperature in A and B will be equal.

C. It is not possible to predict whether A or B will have the higher maximum temperature.

D. The temperature in A and B will increase at the same rate.

15. Consider the equations below.

$$CH_4(g) + O_2(g) \rightarrow HCHO(l) + H_2O(l) \qquad \Delta H^{\ominus} = x$$

$$HCHO(l) + \tfrac{1}{2}O_2(g) \rightarrow HCOOH(l) \qquad \Delta H^{\ominus} = y$$

$$2HCOOH(l) + \tfrac{1}{2}O_2(g) \rightarrow (COOH)_2(s) + H_2O(l) \qquad \Delta H^{\ominus} = z$$

What is the enthalpy change of the reaction below?

$$2CH_4(g) + 3\tfrac{1}{2}O_2(g) \rightarrow (COOH)_2(s) + 3H_2O(l)$$

A. $x + y + z$

B. $2x + y + z$

C. $2x + 2y + z$

D. $2x + 2y + 2z$

16. Given the enthalpy change for the reaction below:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \qquad \Delta H^{\ominus} = -572 \text{ kJ}$$

which statement is correct?

A. The standard enthalpy change of combustion of $H_2(g)$ is –286 kJ mol^{-1}.

B. The standard enthalpy change of combustion of $H_2(g)$ is +286 kJ mol^{-1}.

C. The standard enthalpy change of formation of $H_2O(l)$ is –572 kJ mol^{-1}.

D. The standard enthalpy change of formation of $H_2O(l)$ is +572 kJ mol^{-1}.

17. Which is a correct definition of lattice enthalpy?

A. It is the enthalpy change that occurs when an electron is removed from 1 mol of gaseous atoms.

B. It is the enthalpy change that occurs when 1 mol of a compound is formed from its elements.

C. It is the enthalpy change that occurs when 1 mol of solid crystal changes into a liquid.

D. It is the enthalpy change that occurs when 1 mol of solid crystal is formed from its gaseous ions.

18. Which reaction has the largest increase in entropy?

A. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

B. $Al(OH)_3(s) + NaOH(aq) \rightarrow Al(OH)_4^-(aq) + Na^+(aq)$

C. $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$

D. $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$

19. Which changes increase the rate of the reaction below?

$$C_4H_{10}(g) + Cl_2(g) \rightarrow C_4H_9Cl(l) + HCl(g)$$

I. Increase of pressure

II. Increase of temperature

III. Removal of $HCl(g)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

20. Consider the following reaction.

$$2P + Q \rightarrow R + S$$

This reaction occurs according to the following mechanism.

$$P + Q \rightarrow X \quad \textit{slow}$$
$$P + X \rightarrow R + S \quad \textit{fast}$$

What is the rate expression?

A. rate = k [P]

B. rate = k [P][X]

C. rate = k [P][Q]

D. rate = k $[P]^2$ [Q]

21. What happens when the temperature of a reaction increases?

A. The activation energy increases.

B. The rate constant increases.

C. The enthalpy change increases.

D. The order of the reaction increases.

22. What is the effect of an increase of temperature on the yield and the equilibrium constant for the following reaction?

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(l) \qquad \Delta H^{\ominus} = -128\,kJ$$

	Yield	Equilibrium constant
A.	Increases	Increases
B.	Increases	Decreases
C.	Decreases	Increases
D.	Decreases	Decreases

23. Which statements about a liquid are correct?

I. When the temperature of a liquid in a closed container increases, its vapour pressure increases.

II. When the pressure on a liquid increases, its boiling point increases.

III. When the pressure on a liquid increases, its vapour pressure increases.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

24. What is the conjugate base of H_2CO_3 according to the Brønsted-Lowry theory?

A. CO_3^{2-}

B. HCO_3^-

C. $H_3CO_3^+$

D. CO_2

25. A solution of acid A has a pH of 1 and a solution of acid B has a pH of 2. Which statement **must** be correct?

A. Acid A is stronger than acid B

B. [A] > [B]

C. The concentration of H^+ ions in A is higher than in B

D. The concentration of H^+ ions in B is twice the concentration of H^+ ions in A

26. Which mixtures act as buffer solutions?

I. 100 cm^3 0.1 mol dm^{-3} ethanoic acid and 100 cm^3 0.1 mol dm^{-3} sodium ethanoate

II. 100 cm^3 0.1 mol dm^{-3} ethanoic acid and 50 cm^3 0.1 mol dm^{-3} sodium hydroxide

III. 100 cm^3 0.1 mol dm^{-3} ethanoic acid and 100 cm^3 0.5 mol dm^{-3} sodium hydroxide

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

27. Which solutions have a pH less than 7?

I. $Na_2CO_3(aq)$

II. $[Fe(H_2O)_6]Cl_3(aq)$

III. $(NH_4)_2SO_4(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

28. Equal volumes and concentrations of hydrochloric acid and ethanoic acid are titrated with sodium hydroxide solutions of the same concentration. Which statement is correct?

A. The initial pH values of both acids are equal.

B. At the equivalence points, the solutions of both titrations have pH values of 7.

C. The same volume of sodium hydroxide is needed to reach the equivalence point.

D. The pH values of both acids increase equally until the equivalence points are reached.

29. Bromophenol blue changes from yellow to blue over the pH range of 3.0 to 4.6. Which statement is correct?

A. Molecules of bromophenol blue, HIn, are blue.

B. At pH < 3.0, a solution of bromophenol blue contains more ions, In^-, than molecules, HIn.

C. The pK_a of bromophenol blue is between 3.0 and 4.6.

D. Bromophenol blue is a suitable indicator to titrate ethanoic acid with potassium hydroxide solution.

30. Consider the following reaction.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

Which statement is correct?

A. MnO_4^- is the oxidizing agent and it loses electrons.

B. MnO_4^- is the reducing agent and it loses electrons.

C. MnO_4^- is the oxidizing agent and it gains electrons.

D. MnO_4^- is the reducing agent and it gains electrons.

31. The following equations indicate reactions that occur spontaneously.

$$Fe(s) + NiCl_2(aq) \rightarrow FeCl_2(aq) + Ni(s)$$

$$Zn(s) + FeCl_2(aq) \rightarrow ZnCl_2(aq) + Fe(s)$$

$$Ni(s) + PbCl_2(aq) \rightarrow NiCl_2(aq) + Pb(s)$$

Which is the **increasing** order of the reactivity of the metals?

A. Fe < Ni < Zn < Pb

B. Pb < Ni < Fe < Zn

C. Ni < Zn < Pb < Fe

D. Zn < Fe < Ni < Pb

32. A voltaic cell is made by connecting two half-cells represented by the half-equations below.

$$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s) \qquad E^{\ominus} = -1.19\ V$$

$$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s) \qquad E^{\ominus} = -0.13\ V$$

Which statement is correct about this voltaic cell?

A. Mn is oxidized and the voltage of the cell is 1.06 V.

B. Pb is oxidized and the voltage of the cell is 1.06 V.

C. Mn is oxidized and the voltage of the cell is 1.32 V.

D. Pb is oxidized and the voltage of the cell is 1.32 V.

33. For the electrolysis of aqueous copper(II) sulfate, which of the following statements is correct?

A. Cu and O_2 are produced in a mol ratio of 1:1

B. H_2 and O_2 are produced in a mol ratio of 1:1

C. Cu and O_2 are produced in a mol ratio of 2:1

D. H_2 and O_2 are produced in a mol ratio of 2:1

34. Which of the following substances are structural isomers of each other?

I. $CH_3(CH_2)_3CH_3$

II. $(CH_3)_2CHCH_3$

III. $CH_3CH(CH_3)CH_2CH_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

35. Which reaction pathway describes how ethanol can be formed?

A. ethene $\xrightarrow{\text{addition}}$ chloroethane $\xrightarrow{\text{elimination}}$ ethanol

B. ethane $\xrightarrow{\text{substitution}}$ chloroethane $\xrightarrow{\text{nucleophilic substitution}}$ ethanol

C. ethene $\xrightarrow{\text{substitution}}$ ethanol

D. ethane $\xrightarrow{\text{addition}}$ ethanol

36. By which reactants and type of reaction can ethylamine (aminoethane) be produced?

	Reactants	**Type of reaction**
A.	$CH_3Br + NH_3$	Nucleophilic substitution
B.	$CH_3CH_2Br + NH_3$	Reduction
C.	$CH_3CN + H_2$	Nucleophilic substitution
D.	$CH_3CN + H_2$	Reduction

37. Which compound is an amide?

A. CH_3COOCH_3

B. CH_3CONH_2

C. CH_3NH_2

D. $CH_2(NH_2)COOH$

38. Which process can produce a polyester?

A. Addition polymerization of a dicarboxylic acid

B. Condensation polymerization of a diol and a dicarboxylic acid

C. Addition polymerization of a diol and dicarboxylic acid

D. Condensation polymerization of a dicarboxylic acid

39. Which statement about stereoisomers is correct?

A. 1,2-dichloroethane has two geometrical isomers.

B. 1,2-dichloroethane has two optical isomers.

C. 1,2-dichloroethene has two geometrical isomers.

D. 1,2-dichloroethene has two optical isomers.

40. Density can be calculated by dividing mass by volume. 0.20 ± 0.02 g of a metal has a volume of 0.050 ± 0.005 cm^3. How should its density be recorded using this data?

A. 4.0 ± 0.025 g cm^{-3}

B. 4.0 ± 0.8 g cm^{-3}

C. 4.00 ± 0.025 g cm^{-3}

D. 4.00 ± 0.8 g cm^{-3}