22086113

International Baccalaureate
Baccalauréat International
Bachillerato Internacional

CHEMISTRY
HIGHER LEVEL
PAPER 1

Thursday 8 May 2008 (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

Atomic Number
Element
Atomic Mass

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)															

†	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 amount of **atoms**, in moles, in 88 g of carbon dioxide?

A. 6.02×10^{23}

B. 1.204×10^{24}

C. 6

D. 1

2. The isotopic abundances for an element, X, are $^{28}_{14}X = 20\%$ and $^{29}_{14}X = 80\%$. What is the relative atomic mass of element X?

A. 14

B. 28.2

C. 28.5

D. 28.8

3. What is the volume (in cm^3) of a 0.800 mol dm^{-3} solution of KOH needed for neutralization in a titration with 30.0 cm^3 of 0.200 mol dm^{-3} H_2SO_4?

A. 7.50

B. 60.0

C. 15.0

D. 30.0

4. Which of the following describes the visible emission spectrum of hydrogen?

A. A set of lines which are randomly spaced.

B. A set of lines which converge towards a low energy value.

C. A set of lines which converge towards a long wavelength value.

D. A set of lines which converge towards a high frequency value.

5. Which statement about ionization energy is correct?

A. First ionization energies decrease across period 3.

B. Second ionization energies refer to the removal of two electrons from an atom.

C. Third ionization energies always involve the removal of an electron from a p-orbital.

D. The fourth ionization energy of an element is always greater than its third ionization energy.

6. What is the correct sequence for the stages of operation in a mass spectrometer?

A.	ionization	vaporization	acceleration	deflection
B.	ionization	vaporization	deflection	acceleration
C.	vaporization	acceleration	ionization	deflection
D.	vaporization	ionization	acceleration	deflection

7. Which properties vary in the same way down groups 1 and 7 of the periodic table?

I. Boiling points
II. Ionic radii
III. Atomic radii

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which statements support the description of aluminium oxide as amphoteric?

I. It can show acidic behaviour in the presence of strong alkalis.
II. It can show alkaline behaviour in the presence of strong acids.
III. It dissolves in water to form a neutral solution.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. Which of these species involves the transition metal in one of its common oxidation states?

I. $Cr_2O_7^{2-}$
II. MnO_4^{3-}
III. $FeCl_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

10. Which statement about the chlorides of period 3 elements is correct?

A. The metal chlorides form alkaline solutions when added to water.

B. The non-metal chlorides form acidic solutions when added to water.

C. Al_2Cl_6 is a good conductor of electricity when molten.

D. $SiCl_4$ exists as a giant covalent structure.

11. What are the correct formulas of magnesium nitride and aluminium sulfide?

A. Mg_2N_3 and Al_2S_3

B. Mg_3N_2 and Al_2S_3

C. Mg_2N_3 and Al_3S_2

D. Mg_3N_2 and Al_3S_2

12. Which species has the same electron configuration as a Ca^{2+} ion?

A. Al^{3+} ion

B. Br^{-} ion

C. Ar atom

D. K atom

13. When are ionic bonds most likely to form?

A. When two elements with high electronegativity values react with each other.

B. When two metals of different groups react with each other.

C. When two non metallic elements react with each other.

D. When a metal and a non metal react with each other.

14. What is the shape of PF_5?

A. Tetrahedral

B. Trigonal pyramidal

C. Square planar

D. Trigonal bipyramidal

15. The formula of tetrachloromethane is CCl_4. Which combination correctly shows the number of lone pairs of electrons in the Lewis structure, the shape of the molecule and the type of hybridization of the carbon atom?

	Lone pairs of electrons in Lewis Structure	Shape of molecule	Type of hybridization
A.	4	pyramidal	sp^2
B.	8	square planar	sp^2
C.	12	tetrahedral	sp^3
D.	16	tetrahedral	sp^3

16. A gas sample occupies a volume V_1 at a pressure P_1 and a Kelvin temperature T_1. What would be the temperature of the gas, T_2, if both its pressure and volume are doubled?

A. $T_2 = \frac{1}{2}T_1$

B. $T_2 = T_1$

C. $T_2 = 2T_1$

D. $T_2 = 4T_1$

17. A possible method of preparing hydrogen peroxide is:

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^\ominus = x$$

$$H_2O(l) + \tfrac{1}{2}O_2(g) \rightarrow H_2O_2(l) \qquad \Delta H^\ominus = y$$

Which expression can be used to calculate the enthalpy change for the decomposition of hydrogen peroxide using this data?

$$H_2O_2(l) \rightarrow H_2(g) + O_2(g)$$

A. $-x - y$

B. $x + y$

C. $-x + y$

D. $x - y$

18. Which of the following is correct about the energy changes during bond breaking and bond formation?

	Bond breaking	**Bond formation**
A.	exothermic	endothermic
B.	exothermic	exothermic
C.	endothermic	endothermic
D.	endothermic	exothermic

19. What should be the signs of ΔG, ΔH and ΔS for a chemical reaction to be spontaneous at any temperature?

	ΔG	ΔH	ΔS
A.	positive	negative	positive
B.	negative	negative	negative
C.	negative	negative	positive
D.	negative	positive	negative

20. Which compound has the highest lattice enthalpy?

A. CaO

B. CaS

C. LiF

D. LiI

21. The standard free energy changes of formation of some compounds are shown in the table:

Compound	**MgO(s)**	**H_2O(l)**	**$Mg(OH)_2$(s)**
$\Delta G^{\ominus}_{f}$ / kJ mol^{-1}	– 570	– 237	– 834

Which statement is correct about the following reaction?

$$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$$

A. The reaction is spontaneous and $\Delta G^{\ominus} = +27$ kJ mol^{-1}.

B. The reaction is not spontaneous and $\Delta G^{\ominus} = +27$ kJ mol^{-1}.

C. The reaction is spontaneous and $\Delta G^{\ominus} = -27$ kJ mol^{-1}.

D. The reaction is not spontaneous and $\Delta G^{\ominus} = -27$ kJ mol^{-1}.

22. Which statement explains why increasing the temperature increases the rate of a chemical reaction?

A. More molecules have energy equal to or greater than the activation energy.

B. At a higher temperature the activation energy for the reaction is lower.

C. More molecules have the correct collision geometry.

D. The reaction proceeds according to Le Chatelier's principle.

23. Which statement is correct about the overall order of a chemical reaction?

A. It can be deduced from the stoichiometric coefficients of the equation.

B. It can only be determined experimentally.

C. It is always affected when the concentrations of the reactants are increased.

D. It is always the same as the molecularity.

24. The rate expression for the decomposition of X is

$$\text{rate} = k\,[\text{X}]$$

Values of half-life were measured at intervals during the decomposition.
Which of the following shows the correct **intervals** for the successive half lives (in minutes)?

A. 0.2, 0.4, 0.6, 0.8

B. 0.4, 0.4, 0.4, 0.4

C. 0.8, 0.6, 0.4, 0.2

D. 0.8, 0.4, 0.2, 0.1

25. Consider the following reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92\,\text{kJ}$$

Which of the following affects the value of K_c ?

A. Adding a catalyst

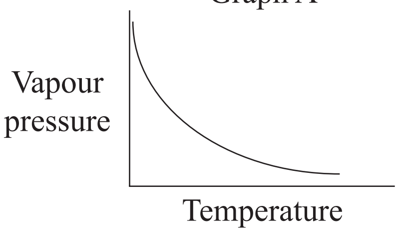
B. Increasing the pressure

C. Increasing the concentrations of nitrogen and hydrogen

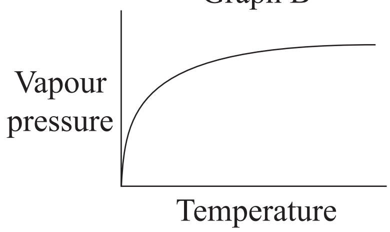
D. Increasing the temperature

26. Which graph correctly shows the variation of vapour pressure with temperature for a liquid?

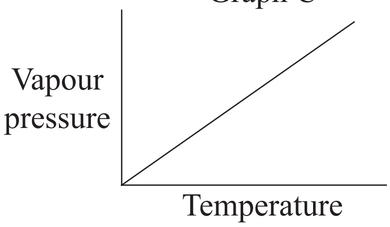
Graph A



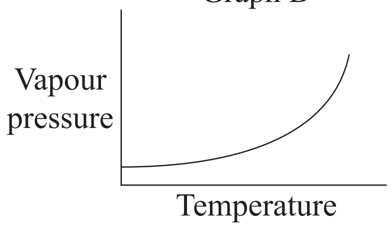
Graph B



Graph C



Graph D



A. Graph A

B. Graph B

C. Graph C

D. Graph D

27. Consider the ionization of water at 25 ºC:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \qquad K_w = 1.0 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$$

However, at 37 ºC, $K_w = 2.4 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$. What can be deduced from this?

A. The pH value of pure water decreases when heated.

B. The enthalpy of ionization of water is negative.

C. The $[OH^-]$ at 37 ºC is lower than 25 ºC.

D. The conductivity of water at 37 ºC is lower than at 25 ºC.

28. What pair of solutions can be used to prepare a buffer solution?

A. $CH_3COONa\,(aq)\,/\,NaOH\,(aq)$

B. $NH_3\,(aq)\,/\,NH_4NO_3\,(aq)$

C. $NH_4Cl\,(aq)\,/\,HCl\,(aq)$

D. $HNO_3\,(aq)\,/\,NaNO_3\,(aq)$

29. Which equations represent acid-base reactions according to the Lewis theory?

I. $2H_2(g) + O_2(g) \rightarrow 2H_2O\,(l)$

II. $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq)$

III. $H^+(aq) + NH_3(aq) \rightarrow NH_4^+(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

30. Which of the following compounds will produce an alkaline solution when dissolved in water?

A. $NaCl$

B. NH_4Cl

C. CH_3COONa

D. CH_3COONH_4

31. Which of the following are conjugate acid-base pairs?

I. $H_2O(l)$ / $OH^-(aq)$
II. $NH_4^+(aq)$ / $NH_3(aq)$
III. $HCl(aq)$ / $NaOH(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

32. What is the oxidation number of vanadium in the compound $NaVO_3$?

A. –1

B. 0

C. +2

D. +5

33. Which statement about electrochemical cells is correct?

A. The reaction in a voltaic cell is spontaneous.

B. The reaction in an electrolytic cell is spontaneous.

C. The reaction in a voltaic cell uses electrical energy.

D. The reaction in an electrolytic cell produces electrical energy.

34. What is the coefficient for $H^+(aq)$, when this redox equation is balanced using whole numbers?

$$Cr_2O_7^{2-}(aq) + Cl^-(aq) + H^+(aq) \rightarrow Cr^{3+}(aq) + Cl_2(g) + H_2O(l)$$

A. 7

B. 2

C. 14

D. 1

35. Dilute sulfuric acid is electrolyzed using inert electrodes. What product, and in what relative amount, is produced at each electrode?

	Positive electrode	Negative electrode
A.	1 mol H_2	2 mol O_2
B.	1 mol O_2	2 mol H_2
C.	2 mol H_2	1 mol O_2
D.	2 mol O_2	1 mol H_2

36. Which molecule has a chiral carbon atom?

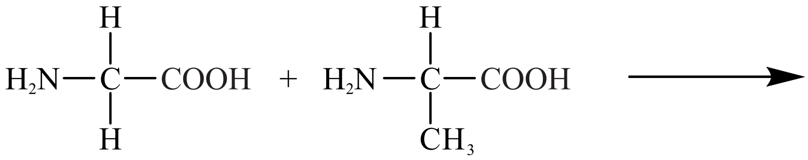
A. $CH_2CClCH_2CH_3$

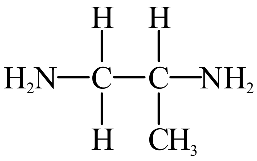
B. $CH_3CHOHCH_2CH_3$

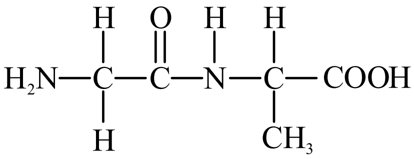
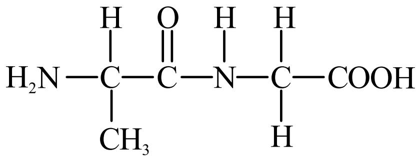
C. $(CH_3)_2CHCH_2CH_3$

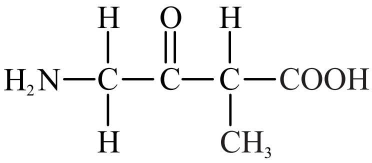
D. H_2NCH_2COOH

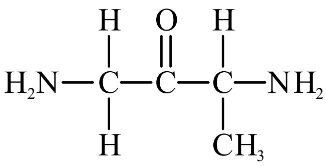
37. Which organic product(s) could form when 2-aminoethanoic acid reacts with 2-aminopropanoic acid?



A.  only

B.  and 

C.  only

D.  only

38. Which statement is correct about the determination of the structure of organic compounds?

A. Mass spectrometry is the best technique to provide information on the chemical environment of all the hydrogen atoms in a molecule.

B. ^{1}H NMR spectroscopy provides the values of carbon-hydrogen bond distances present in a molecule.

C. Infrared spectroscopy is used to determine all the bond angles and bond distances in a molecule.

D. Mass spectrometry can provide information about the relative molecular mass of a compound.

39. Which statement best describes the reaction mechanism involved in the single step conversion of chloroethane to ethanol?

A. The reaction involves removal of HCl, followed by the addition of H_2O.

B. The reaction involves heterolytic fission of the C–Cl bond, followed by a reaction with H_2O.

C. The reaction involves nucleophilic attack of OH^- in a bimolecular mechanism.

D. The reaction mechanism involves a carbocation.

40. Which statement about alcohols is correct?

A. Primary alcohols can be obtained by the reduction of carboxylic acids or aldehydes.

B. Secondary alcohols can be obtained by the oxidation of ketones.

C. Tertiary alcohols can be obtained by the reduction of carboxylic acids and ketones.

D. Alcohols can be obtained by the addition of water to alkanes, using acid as a catalyst.