IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N05/4/CHEMI/HPM/ENG/TZ0/XX+

CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 7 November 2005 (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

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. The complete oxidation of propane produces carbon dioxide and water as shown below.

$$C_3H_8 + \_\_ O_2 \rightarrow \_\_ CO_2 + \_\_ H_2O$$

What is the total of the coefficients for the **products** in the balanced equation for 1 mole of propane?

A. 6

B. 7

C. 12

D. 13

2. The relative molecular mass (M_r) of a compound is 60. Which formulas are possible for this compound?

I. $CH_3CH_2CH_2NH_2$

II. $CH_3CH_2CH_2OH$

III. $CH_3CH(OH)CH_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

3. Which aqueous solution contains the most hydrogen ions?

A. 20 cm^3 of 2 mol dm^{-3} sulfuric acid

B. 10 cm^3 of 4 mol dm^{-3} nitric acid

C. 80 cm^3 of 0.5 mol dm^{-3} hydrochloric acid

D. 40 cm^3 of 0.5 mol dm^{-3} sulfuric acid

4. Information is given about four different atoms:

atom	neutrons	protons
W	22	18
X	18	20
Y	22	16
Z	20	18

Which **two** atoms are isotopes?

A. W and Y

B. W and Z

C. X and Z

D. X and Y

5. Which equation represents the third ionization energy of an element M?

A. $M^{+}(g) \rightarrow M^{4+}(g) + 3e^{-}$

B. $M^{2+}(g) \rightarrow M^{3+}(g) + e^{-}$

C. $M(g) \rightarrow M^{3+}(g) + 3e^{-}$

D. $M^{3+}(g) \rightarrow M^{4+}(g) + e^{-}$

6. Which statement is correct about a line emission spectrum?

A. Electrons absorb energy as they move from low to high energy levels.

B. Electrons absorb energy as they move from high to low energy levels.

C. Electrons release energy as they move from low to high energy levels.

D. Electrons release energy as they move from high to low energy levels.

7. Which factors lead to an element having a low value of first ionization energy?

I. large atomic radius

II. high number of occupied energy levels

III. high nuclear charge

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which particles can act as ligands in complex ion formation?

I. Cl^-

II. NH_3

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. When the following bond types are listed in decreasing order of strength (strongest first), what is the correct order?

A. covalent > hydrogen > van der Waals'

B. covalent > van der Waals' > hydrogen

C. hydrogen > covalent > van der Waals'

D. van der Waals' > hydrogen > covalent

10. What is the valence shell electron pair repulsion (VSEPR) theory used to predict?

A. the energy levels in an atom

B. the shapes of molecules and ions

C. the electronegativities of elements

D. the type of bonding in compounds

11. Which statement about electronegativity is correct?

A. Electronegativity decreases across a period.

B. Electronegativity increases down a group.

C. Metals generally have lower electronegativity values than non-metals.

D. Noble gases have the highest electronegativity values.

12. Which statements correctly describe the NO_2^- ion?

I. It can be represented by resonance structures.

II. It has two lone pairs of electrons on the N atom.

III. The N atom is sp^2 hybridized.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. Which substance is most similar in shape to NH_3?

A. GaI_3

B. BF_3

C. $FeCl_3$

D. PBr_3

14. Why does the temperature of boiling water remain constant even though heat is supplied at a constant rate?

A. Heat is lost to the surroundings.

B. The heat is used to break the covalent bonds in the water molecules.

C. Heat is also taken in by the container.

D. The heat is used to overcome the intermolecular forces of attraction between water molecules.

15. The following equation shows the formation of magnesium oxide from magnesium metal.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \qquad \Delta H^{\ominus} = -1204kJ$$

Which statement is correct for this reaction?

A. 1204kJ of energy are released for every mol of magnesium reacted.

B. 602kJ of energy are absorbed for every mol of magnesium oxide formed.

C. 602kJ of energy are released for every mol of oxygen gas reacted.

D. 1204kJ of energy are released for every two mol of magnesium oxide formed.

16. The following equations show the oxidation of carbon and carbon monoxide to carbon dioxide.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = -x \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = -y \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for the oxidation of carbon to carbon monoxide?

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

A. $x + y$

B. $-x - y$

C. $y - x$

D. $x - y$

17. For the reaction

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

the bond enthalpies (in kJ mol^{-1}) are

H–H	x
O=O	y
O–H	z

Which calculation will give the value, in kJ mol^{-1}, of $\Delta H^{\ominus}$ for the reaction?

A. $2x + y - 2z$

B. $4z - 2x - y$

C. $2x + y - 4z$

D. $2z - 2x - y$

18. For the reaction,

$$2CaO(s) \rightarrow 2Ca(s) + O_2(g)$$

at 1 atmosphere the values of $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ are both positive. Which statement is correct?

A. $\Delta G^{\ominus}$ is temperature dependent.

B. The change in entropy is the driving force of the reaction.

C. At high temperatures ΔG is positive.

D. The reverse reaction is endothermic.

19. Which statement is correct for a collision between reactant particles leading to a reaction?

A. Colliding particles must have different energy.

B. All reactant particles must have the same energy.

C. Colliding particles must have a kinetic energy higher than the activation energy.

D. Colliding particles must have the same velocity.

20. The reaction $2X(g) + Y(g) \rightarrow 3Z(g)$ has the rate expression

$$\text{rate} = k[X]^2[Y]^0$$

The concentration of X is increased by a factor of three and the concentration of Y is increased by a factor of two. By what factor will the reaction rate increase?

A. 6

B. 9

C. 12

D. 18

21. To what does A refer in the Arrhenius equation $k = Ae^{-Ea/RT}$?

A. activation energy

B. rate constant

C. gas constant

D. collision geometry

22. Which changes will shift the position of equilibrium to the right in the following reaction?

$$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$$

I. adding a catalyst

II. decreasing the oxygen concentration

III. increasing the volume of the container

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

23. Hydrogen and carbon dioxide react as shown in the equation below.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

For this reaction the values of K_c with different temperatures are

Temperature/K	K_c
500	7.76×10^{-3}
700	1.23×10^{-1}
900	6.01×10^{-1}

Which statement for the reaction is correct?

A. The forward reaction is endothermic.

B. $H_2O(g)$ and $CO(g)$ are more stable than $H_2(g)$ and $CO_2(g)$.

C. The reaction goes almost to completion at high temperatures.

D. The reverse reaction is favoured by high temperatures.

24. When the following 1.0 mol dm^{-3} solutions are listed in increasing order of pH (lowest first), what is the correct order?

A. $HNO_3 < H_2CO_3 < NH_3 < Ba(OH)_2$

B. $NH_3 < Ba(OH)_2 < H_2CO_3 < HNO_3$

C. $Ba(OH)_2 < H_2CO_3 < NH_3 < HNO_3$

D. $HNO_3 < H_2CO_3 < Ba(OH)_2 < NH_3$

25. Which compound will dissolve in water to give a solution with a pH greater than 7?

A. sodium chloride

B. potassium carbonate

C. ammonium nitrate

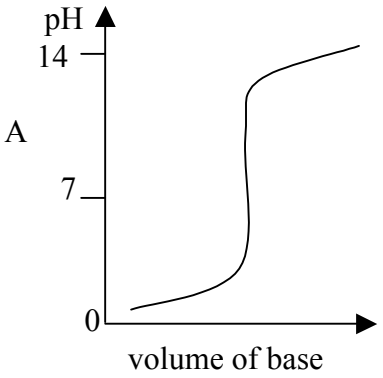
D. lithium sulfate

26. An aqueous solution has a pH of 10. Which concentrations are correct for the ions below?

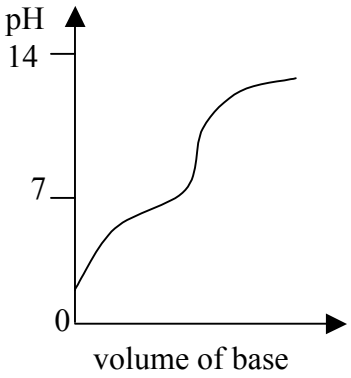
	$[H^+(aq)]$ mol dm^{-3}	$[OH^-(aq)]$ mol dm^{-3}
A.	10^4	10^{-10}
B.	10^{-4}	10^{-10}
C.	10^{-10}	10^{-4}
D.	10^{-10}	10^4

27. Which graph shows how the pH changes when a weak base is added to a strong acid?

A



B



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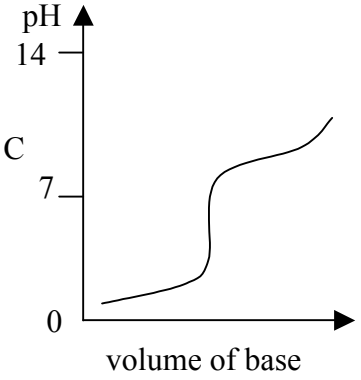

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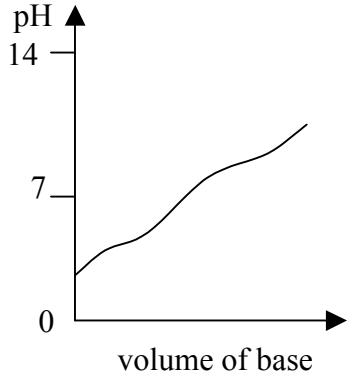


28. When the following acids are listed in decreasing order of acid strength (strongest first), what is the correct order?

	K_a
benzoic	6.31×10^{-5}
chloroethanoic	1.38×10^{-3}
ethanoic	1.74×10^{-5}

A. chloroethanoic > benzoic > ethanoic

B. benzoic > ethanoic > chloroethanoic

C. chloroethanoic > ethanoic > benzoic

D. ethanoic > benzoic > chloroethanoic

29. Which equation represents a redox reaction?

A. $KOH(aq) + HC1(aq) \rightarrow KC1(aq) + H_2O(l)$

B. $Mg(s) + 2HC1(aq) \rightarrow MgCl_2(aq) + H_2(g)$

C. $CuO(s) + 2HC1(aq) \rightarrow CuC1_2(aq) + H_2O(l)$

D. $ZnCO_3(s) + 2HC1(aq) \rightarrow ZnC1_2(aq) + CO_2(g) + H_2O(1)$

30. The following information is given about reactions involving the metals X, Y and Z and solutions of their sulfates.

$$X(s) + YSO_4(aq) \rightarrow \text{ no reaction}$$
$$Z(s) + YSO_4(aq) \rightarrow Y(s) + ZSO_4(aq)$$

When the metals are listed in decreasing order of reactivity (most reactive first), what is the correct order?

A. $Z > Y > X$

B. $X > Y > Z$

C. $Y > X > Z$

D. $Y > Z > X$

31. What is the total of **all** the coefficients in the balanced equation for the reduction of 1 mol of MnO_4^- ?

$$\_\_ MnO_4^- + \_\_ H^+ + \_\_ e^- \rightarrow \_\_ Mn^{2+} + \_\_ H_2O$$

A. 5

B. 9

C. 17

D. 19

32. From the given standard electrode potentials which statement is correct?

$$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s) \qquad E^{\ominus} = -2.87V$$
$$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s) \qquad E^{\ominus} = -0.23V$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^{\ominus} = +0.77V$$

A. $Ca^{2+}(aq)$ can oxidize Ni(s)

B. $Ni^{2+}(aq)$ can reduce $Ca^{2+}(aq)$

C. $Fe^{3+}(aq)$ can oxidize Ni(s)

D. $Fe^{3+}(aq)$ can reduce $Ca^{2+}(aq)$

33. Which statement is correct about the electrolysis of copper(II) sulfate solution using graphite electrodes?

A. A colourless gas is produced at the negative electrode.

B. The electrolyte does not change colour.

C. The negative electrode decreases in mass.

D. A colourless gas is produced at the positive electrode.

34. How many structural isomers are possible with the molecular formula C_6H_{14} ?

A. 4

B. 5

C. 6

D. 7

35. Which compound can exist as optical isomers?

A. $CH_3CHBrCH_3$

B. $CH_2ClCH(OH)CH_2Cl$

C. $CH_3CHBrCOOH$

D. $CH_3CCl_2CH_2OH$

36. Which type of compound can be made in one step from a secondary alcohol?

A. an aldehyde

B. an alkane

C. a carboxylic acid

D. a ketone

37. How many peaks are there in the ^1H NMR spectrum of ethanol?

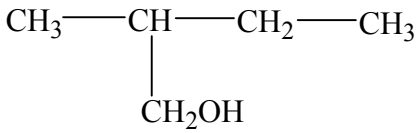
A. 2

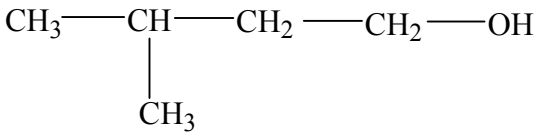
B. 3

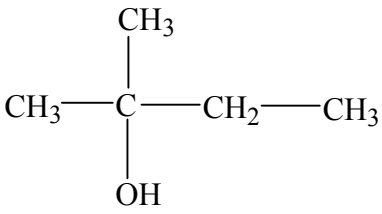
C. 5

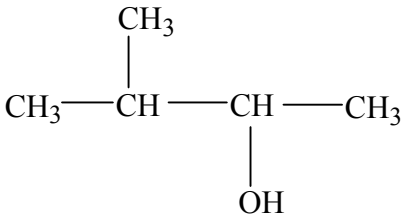
D. 6

38. Which formula represents a tertiary alcohol?

A. 

B. 

C. 

D. 

39. Which reaction type is typical for halogenoalkanes?

A. nucleophilic substitution

B. electrophilic substitution

C. electrophilic addition

D. nucleophilic addition

40. Which substance is **not** readily oxidized by acidified potassium dichromate(VI) solution?

A. propan-1-ol

B. propan-2-ol

C. propanal

D. propanone