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

N04/4/CHEMI/HPM/ENG/TZ0/XX

88046101

CHEMISTRY
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PAPER 1

Wednesday 17 November 2004 (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

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. Consider the following equation.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

How many moles of $CO_2(g)$ are produced by the complete combustion of 58 g of butane, $C_4H_{10}(g)$?

A. 4

B. 8

C. 12

D. 16

2. 6.0 moles of $Fe_2O_3(s)$ reacts with 9.0 moles of carbon in a blast furnace according to the equation below.

$$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(s) + 3CO(g)$$

What is the limiting reagent and hence the theoretical yield of iron?

	Limiting reagent	**Theoretical yield of iron**
A.	Fe_2O_3	6.0 mol
B.	Fe_2O_3	12.0 mol
C.	carbon	9.0 mol
D.	carbon	6.0 mol

3. What volume of 0.500 $mol\,dm^{-3}$ HCl(aq) is required to react completely with 10.0 g of calcium carbonate according to the equation below?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

A. 100 cm^3

B. 200 cm^3

C. 300 cm^3

D. 400 cm^3

4. A certain sample of element Z contains 60% of ^{69}Z and 40% of ^{71}Z. What is the relative atomic mass of element Z in this sample?

A. 69.2

B. 69.8

C. 70.0

D. 70.2

5. Which ion would undergo the greatest deflection in a mass spectrometer?

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

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

C. $^{18}O^{2+}$

D. $(^{16}O^{18}O)^{+}$

6. Rubidium is an element in the same group of the periodic table as lithium and sodium. It is likely to be a metal which has a

A. high melting point and reacts slowly with water.

B. high melting point and reacts vigorously with water.

C. low melting point and reacts vigorously with water.

D. low melting point and reacts slowly with water.

7. When the following species are arranged in order of **increasing** radius, what is the correct order?

A. Cl^{-}, Ar, K^{+}

B. K^{+}, Ar, Cl^{-}

C. Cl^{-}, K^{+}, Ar

D. Ar, Cl^{-}, K^{+}

8. The cyanide ion, CN^-, can form two complex ions with iron ions. The formulas of these ions are $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$. What is the oxidation state of iron in the two complex ions?

	$[Fe(CN)_6]^{4-}$	$[Fe(CN)_6]^{3-}$
A.	– 4	–3
B.	+2	+3
C.	+3	+2
D.	–3	– 4

9. Which molecule is linear?

A. SO_2

B. H_2S

C. CO_2

D. Cl_2O

10. Why is the boiling point of PH_3 lower than that of NH_3?

A. PH_3 is non-polar whereas NH_3 is polar.

B. PH_3 is not hydrogen bonded whereas NH_3 is hydrogen bonded.

C. Van der Waals' forces are weaker in PH_3 than in NH_3.

D. The molar mass of PH_3 is greater than that of NH_3.

11. Which molecule is non-polar?

A. H_2CO

B. $CHCl_3$

C. NF_3

D. SO_3

12. NO_3^- is trigonal planar and NH_3 is trigonal pyramidal. What is the approximate hybridization of N in each of these species?

	N in NO_3^-	**N in NH_3**
A.	sp^2	sp^3
B.	sp^2	sp^2
C.	sp^3	sp^2
D.	sp^3	sp^3

13. Consider the following statements.

I. All carbon-oxygen bond lengths are equal in CO_3^{2-}.

II. All carbon-oxygen bond lengths are equal in CH_3COOH.

III. All carbon-oxygen bond lengths are equal in CH_3COO^-.

Which statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. The temperature in Kelvin of 2.0 dm^3 of an ideal gas is doubled and its pressure is increased by a factor of four. What is the final volume of the gas?

A. 1.0 dm^3

B. 2.0 dm^3

C. 3.0 dm^3

D. 4.0 dm^3

15. Consider the following equations.

$$Mg(s) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s) \qquad \Delta H^{\ominus} = -602 \text{ kJ}$$
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H^{\ominus} = -242 \text{ kJ}$$

What is the $\Delta H^{\ominus}$ value (in kJ) for the following reaction?

$$MgO(s) + H_2(g) \rightarrow Mg(s) + H_2O(g)$$

A. – 844

B. – 360

C. + 360

D. + 844

16. For which of the following is the sign of the enthalpy change different from the other three?

A. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

B. $Na(g) \rightarrow Na^+(g) + e^-$

C. $CO_2(s) \rightarrow CO_2(g)$

D. $2Cl(g) \rightarrow Cl_2(g)$

17. Separate solutions of HCl(aq) and H_2SO_4(aq) of the same concentration and same volume were completely neutralized by NaOH(aq). X kJ and Y kJ of heat were evolved respectively. Which statement is correct?

A. $X = Y$

B. $Y = 2X$

C. $X = 2Y$

D. $Y = 3X$

18. The enthalpy change, $\Delta H^{\ominus}$, for a chemical reaction is $-10\ \text{kJ mol}^{-1}$ and the entropy change, $\Delta S^{\ominus}$, is $-10\ \text{J K}^{-1}\ \text{mol}^{-1}$ at 27 °C. What is the value of $\Delta G^{\ominus}$ (in J) for this reaction?

A. −260

B. −7000

C. −9730

D. −13000

19. For a given reaction, why does the rate of reaction increase when the concentrations of the reactants are increased?

A. The frequency of the molecular collisions increases.

B. The activation energy increases.

C. The average kinetic energy of the molecules increases.

D. The rate constant increases.

20. Consider the following statements.

I. The rate constant of a reaction increases with increase in temperature.

II. Increase in temperature decreases the activation energy of the reaction.

III. The term A in the Arrhenius equation ($k = Ae^{\frac{-E_a}{RT}}$) relates to the energy requirements of the collisions.

Which statement(s) is/are correct?

A. I only

B. II only

C. I and III only

D. II and III only

21. For the chemical reaction

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

the following reaction mechanism has been proposed.

$$NO(g) + NO(g) \rightleftharpoons N_2O_2(g) \qquad \text{fast}$$
$$N_2O_2(g) + O_2(g) \rightarrow 2NO_2(g) \qquad \text{slow}$$

What could be the rate equation for this reaction?

A. rate $= k[NO][O_2]$

B. rate $= k[NO]^2$

C. rate $= k[N_2O_2][O_2]$

D. rate $= k[NO]^2[O_2]$

22. What will happen if $CO_2(g)$ is allowed to escape from the following reaction mixture at equilibrium?

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

A. The pH will decrease.

B. The pH will increase.

C. The pH will remain constant.

D. The pH will become zero.

23. The value of the equilibrium constant for the reaction

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

is 0.25 at $440\,^\circ C$. What would the value of the equilibrium constant be for the following reaction at the same temperature?

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

A. 0.25

B. 0.50

C. 2.0

D. 4.0

24. Consider the following equilibria in 0.10 $mol\,dm^{-3}$ carbonic acid.

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$
$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

Which species is present in the highest concentration?

A. $H_2CO_3(aq)$

B. $H^+(aq)$

C. $HCO_3^-(aq)$

D. $CO_3^{2-}(aq)$

25. The acid dissociation constant of a weak acid HA has a value of 1.0×10^{-5} $mol\,dm^{-3}$. What is the pH of a $0.10\ mol\,dm^{-3}$ aqueous solution of HA?

A. 2

B. 3

C. 5

D. 6

26. Which mixture would produce a buffer solution when dissolved in $1.0\ dm^3$ of water?

A. 0.50 mol of CH_3COOH and 0.50 mol of NaOH

B. 0.50 mol of CH_3COOH and 0.25 mol of NaOH

C. 0.50 mol of CH_3COOH and 1.00 mol of NaOH

D. 0.50 mol of CH_3COOH and 0.25 mol of $Ba(OH)_2$

27. Which compound, when dissolved in aqueous solution, has the highest pH?

A. NaCl

B. Na_2CO_3

C. NH_4Cl

D. NH_4NO_3

28. In which reaction is $H_2PO_4^-(aq)$ acting as a Brønsted-Lowry base?

A. $H_2PO_4^-(aq) + NH_3(aq) \rightarrow HPO_4^{2-}(aq) + NH_4^+(aq)$

B. $H_2PO_4^-(aq) + OH^-(aq) \rightarrow HPO_4^{2-}(aq) + H_2O(l)$

C. $H_2PO_4^-(aq) + C_2H_5NH_2(aq) \rightarrow HPO_4^{2-}(aq) + C_2H_5NH_3^+(aq)$

D. $H_2PO_4^-(aq) + CH_3COOH(aq) \rightarrow H_3PO_4(aq) + CH_3COO^-(aq)$

29. Consider the following reaction.

$$H_2SO_3\,(aq) + Sn^{4+}\,(aq) + H_2O\,(l) \rightarrow Sn^{2+}\,(aq) + HSO_4^-\,(aq) + 3H^+\,(aq)$$

Which statement is correct?

A. H_2SO_3 is the reducing agent because it undergoes reduction.

B. H_2SO_3 is the reducing agent because it undergoes oxidation.

C. Sn^{4+} is the oxidizing agent because it undergoes oxidation.

D. Sn^{4+} is the reducing agent because it undergoes oxidation.

30. What happens at the positive electrode in a voltaic cell and in an electrolytic cell?

	Voltaic cell	**Electrolytic cell**
A.	Reduction	Oxidation
B.	Oxidation	Reduction
C.	Oxidation	Oxidation
D.	Reduction	Reduction

31. Consider the following reactions.

$$Cu^{2+}\,(aq) + 2e^- \rightleftharpoons Cu\,(s) \qquad E^{\ominus} = +0.34\ \text{V}$$

$$Mg^{2+}\,(aq) + 2e^- \rightleftharpoons Mg\,(s) \qquad E^{\ominus} = -2.36\ \text{V}$$

$$Zn^{2+}\,(aq) + 2e^- \rightleftharpoons Zn\,(s) \qquad E^{\ominus} = -0.76\ \text{V}$$

Which statement is correct?

A. $Cu^{2+}\,(aq)$ will oxidize both $Mg\,(s)$ and $Zn\,(s)$.

B. $Zn\,(s)$ will reduce both $Cu^{2+}\,(aq)$ and $Mg^{2+}\,(aq)$.

C. $Mg^{2+}\,(aq)$ will oxidize both $Cu\,(s)$ and $Zn\,(s)$.

D. $Cu\,(s)$ will reduce both $Mg^{2+}\,(aq)$ and $Zn^{2+}\,(aq)$.

32. Consider the standard electrode potentials of the following reactions.

$$Cr^{3+}(aq) + 3e^{-} \rightarrow Cr(s) \qquad -0.75\ V$$
$$Cd^{2+}(aq) + 2e^{-} \rightarrow Cd(s) \qquad -0.40\ V$$

What is the value of the cell potential (in V) for the following reaction?

$$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$$

A. – 0.35

B. – 1.15

C. + 0.30

D. + 0.35

33. Aqueous solutions containing different concentrations of NaCl were electrolysed using platinum electrodes. What is the **major** product at the positive electrode in each case?

	0.001 mol dm^{-3} NaCl(aq)	**1.0 mol dm^{-3} NaCl(aq)**
A.	H_2	Na
B.	H_2	H_2
C.	O_2	Cl_2
D.	Cl_2	O_2

34. Which compound has the lowest boiling point?

A. $CH_3CH_2CH(CH_3)CH_3$

B. $(CH_3)_4C$

C. $CH_3CH_2CH_2CH_2CH_3$

D. $CH_3CH_2OCH_2CH_3$

35. Which species will show optical activity?

A. 1-chloropentane

B. 3-chloropentane

C. 1-chloro-2-methylpentane

D. 2-chloro-2-methylpentane

36. What type of reaction does the equation below represent?

$$CH_2{=}CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$$

A. substitution

B. condensation

C. reduction

D. addition

37. Consider the following compounds.

I. $CH_3CH_2CH(OH)CH_3$

II. $CH_3CH(CH_3)CH_2OH$

III. $(CH_3)_3COH$

The compounds are treated separately with acidified potassium dichromate(VI) solution. Which will produce a colour change from orange to green?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

38. Which compound reacts most rapidly by a S_N1 mechanism?

A. $(CH_3)_3CCl$

B. $CH_3CH_2CH_2CH_2Br$

C. $(CH_3)_3CBr$

D. $CH_3CH_2CH_2CH_2Cl$

39. Which compound shows three different environments for hydrogen atoms in the ^1H NMR spectrum?

A. $CH_3CH_2CH_3$

B. CH_2OHCH_2OH

C. $CH_3CH_2CH_2OH$

D. $CH_3CH(OH)CH_3$

40. Which statement is correct regarding the structure of benzene?

A. The ^1H NMR spectrum of benzene shows six different environments for H atoms.

B. Benzene is a symmetrical, planar molecule with three single and three double bonds.

C. The enthalpy change for the hydrogenation of benzene is less exothermic than that of cyclohexatriene.

D. Benzene undergoes addition reactions more readily than substitution reactions.