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

N02/420/H(1)

CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 18 November 2002 (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.

Periodic Table

Atomic Number
Atomic Mass

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)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs**	109 **Mt**									
		†	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 reaction:

$$CaCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$$

$2.0\ dm^3$ of $0.50\ mol\ dm^{-3}$ $CaCl_2(aq)$ is mixed with $1.0\ dm^3$ of $2.0\ mol\ dm^{-3}$ $AgNO_3(aq)$. What are the concentrations of $Ca^{2+}(aq)$ and $NO_3^-(aq)$ after mixing?

	$[Ca^{2+}]$ / mol dm^{-3}	**$[NO_3^-]$ / mol dm^{-3}**
A.	0.66	0.33
B.	0.33	0.66
C.	1.0	2.0
D.	3.0	1.5

2. Formation of polyethene from calcium carbide, CaC_2, can take place as follows:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

$$C_2H_2 + H_2 \rightarrow C_2H_4$$

$$nC_2H_4 \rightarrow -(-CH_2 - CH_2-)_n -$$

What mass of polyethene is obtained from 64 kg of CaC_2 ?

A. 7 kg

B. 14 kg

C. 21 kg

D. 28 kg

3. Ammonia is manufactured by the synthesis of nitrogen and hydrogen as follows:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

56.0 g of N_2 produces 34.0 g of NH_3.

What is the percentage yield of ammonia?

A. 50

B. 68

C. 74

D. 100

4. Isotopes are elements with

A. the same atomic number and the same number of neutrons.

B. the same mass number but a different number of neutrons.

C. the same atomic number but a different number of neutrons.

D. different atomic and mass numbers but the same number of neutrons.

5. A transition metal ion X^{3+} has the electronic configuration $[Ar]\,3d^4$. What is the atomic number of element X?

A. 22

B. 24

C. 25

D. 27

6. Which of the following electronic configurations gives rise to the largest increase between the second and third ionisation energies?

A. $1s^2\ 2s^2$

B. $1s^2\ 2s^2\ 2p^2$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2$

D. $1s^2\ 2s^2\ 2p^6\ 3s^1$

7. Which of the following displacement reactions is possible?

A. $Br_2(aq) + 2Cl^-(aq) \rightarrow 2Br^-(aq) + Cl_2(aq)$

B. $I_2(aq) + 2Cl^-(aq) \rightarrow 2I^-(aq) + Cl_2(aq)$

C. $Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$

D. $I_2(aq) + 2Br^-(aq) \rightarrow 2I^-(aq) + Br_2(aq)$

8. An element E of mass number 40 has the electronic configuration 2. 8. 8. 2. Which statement regarding this element is **not** correct?

A. It belongs to group 2 of the periodic table.

B. It has 20 neutrons.

C. It belongs to period 4 of the periodic table.

D. The formula of its oxide is EO_2.

9. Which ions are listed in order of **decreasing** ionic radius (highest first)?

A. $Mg^{2+}, Na^+, F^-, O^{2-}$

B. $O^{2-}, F^-, Na^+, Mg^{2+}$

C. $F^-, O^{2-}, Na^+, Mg^{2+}$

D. $Mg^{2+}, Na^+, O^{2-}, F^-$

10. Consider the following coordination compounds

I. $[Pt(NH_3)_4]Cl_2$

II. $[Pt(NH_3)_3Cl]Cl$

III. $[Pt(NH_3)_2Cl_2]$

What are the charges on the complex ions?

	I	**II**	**III**
A.	+2	+1	0
B.	–2	–1	0
C.	0	+1	+2
D.	0	–1	–2

11. Which intermolecular forces exist in dry ice, $CO_2(s)$?

A. Covalent bonds

B. Dipole-dipole attractions

C. Van der Waal's forces

D. Hydrogen bonds

12. When the species NH_2^-, NH_3 and NH_4^+ are arranged in **increasing** order of H–N–H bond angle, the correct order is

A. NH_2^-, NH_3, NH_4^+

B. NH_4^+, NH_3, NH_2^-

C. NH_3, NH_4^+, NH_2^-

D. NH_3, NH_2^-, NH_4^+

13. The elements X and Y have the following electronic configurations:

$$\begin{array}{ll} X & 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 \\ Y & 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5 \end{array}$$

What is the formula of the compound formed between X and Y?

A. XY_2

B. X_5Y_2

C. X_2Y_5

D. XY_5

14. Which statements about the following molecule are correct?

$$(CH_3)_2CHCH{=}CHC{\equiv}CCH{=}CH_2$$

I. Three carbon atoms are sp^3 hybridized.

II. Three carbon atoms are sp^2 hybridized.

III. Two carbon atoms are sp hybridized.

A. I and II only

B. I, II and III

C. II and III only

D. I and III only

15. Under what conditions would a given mass of oxygen gas occupy the greatest volume?

A. High temperature and high pressure

B. High temperature and low pressure

C. Low temperature and low pressure

D. Low temperature and high pressure

16. The volume of a gas measured at 27 °C and 101.3 kPa is $20.0\ dm^3$. What final temperature would be required to increase the volume to $40.0\ dm^3$ at 101.3 kPa?

A. 54 °C

B. 300 °C

C. 327 °C

D. 600 °C

17. Consider the following reaction:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) \qquad \Delta H^{\ominus} = ?$$

Bond enthalpies (in $kJ\ mol^{-1}$) involved in the reaction are

N ≡ N	x
H–H	y
N–H	z

Which calculation will give the value of $\Delta H^{\ominus}$?

A. $x + 3y - 6z$

B. $6z - x + 3y$

C. $x - 3y + 6z$

D. $x + 3y - 2z$

18. If 3600 J of heat is added to 180 g of $C_2H_5OH(l)$, its temperature increases from 18.5 °C to 28.5 °C. What is the specific heat capacity of $C_2H_5OH(l)$?

A. 0.500 J g^{-1} °C^{-1}

B 2.00 J g^{-1} °C^{-1}

C. 20.0 J g^{-1} °C^{-1}

D. 200 J g^{-1} °C^{-1}

19. The following reaction takes place in an internal combustion engine:

$$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

What are the signs for $\Delta H^{\ominus}$, $\Delta S^{\ominus}$ and $\Delta G^{\ominus}$ for this reaction?

	$\Delta H^{\ominus}$	$\Delta S^{\ominus}$	$\Delta G^{\ominus}$
A.	–	+	+
B.	–	+	–
C.	–	–	–
D.	+	–	–

20. Consider the following equations:

$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H^{\ominus} = -298 \text{ kJ}$$
$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightarrow SO_3(g) \qquad \Delta H^{\ominus} = -98 \text{ kJ}$$
$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l) \qquad \Delta H^{\ominus} = -130 \text{ kJ}$$
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^{\ominus} = -286 \text{ kJ}$$

What is the standard enthalpy change of formation ($\Delta H^{\ominus}{}_f$) for $H_2SO_4(l)$?

A. –812 kJ

B. +812 kJ

C. –526 kJ

D. +526 kJ

21. In general, the rate of a reaction can be increased by all of the following **except**

A. increasing the temperature.

B. increasing the activation energy.

C. increasing the concentration of reactants.

D. increasing the surface area of the reactants.

22. The following experimental data was obtained for the reaction $X + Y \rightarrow$ products.

[X] / mol dm^{-3}	**[Y] / mol dm^{-3}**	**Initial rate / mol dm^{-3}sec^{-1}**
0.10	0.10	4.0×10^{-4}
0.20	0.20	1.6×10^{-3}
0.50	0.10	1.0×10^{-2}
0.50	0.50	1.0×10^{-2}

What is the order of reaction with respect to X and the order of reaction with respect to Y?

A. 2 and 0

B. 0 and 2

C. 2 and 1

D. 1 and 0

23. The rate of a gaseous reaction is given by the expression rate = k [P][Q]. If the volume of the reaction vessel is reduced to $\frac{1}{4}$ of the initial volume, what will be the ratio of the new rate to the original rate?

A. 1 : 4

B. 1 : 16

C. 4 : 1

D. 16 : 1

24. The volume of the reaction vessel containing the following equilibrium mixture

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$$

is increased. When equilibrium is re-established, which of the following will occur?

A. The amount of $SO_2Cl_2(g)$ will increase.

B. The amount of $SO_2Cl_2(g)$ will decrease.

C. The amount of $Cl_2(g)$ will remain unchanged.

D. The amount of $Cl_2(g)$ will decrease.

25. A $1.0\ dm^3$ reaction vessel contains initially 1.0 mol of $NO_2(g)$ and 1.0 mol of $N_2O_4(g)$. At equilibrium, 0.75 mol of $N_2O_4(g)$ are present. What is the value of K_c?

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

A. 0.33

B. 0.50

C. 2.0

D. 3.0

26. What affects the amount of $X_3Y(g)$ at equilibrium in the following exothermic reaction?

$$3X(g) + Y(g) \rightleftharpoons X_3Y(g)$$

A. Temperature, pressure and a catalyst

B. Temperature and pressure

C. Temperature only

D. Pressure only

27. When the following $0.10\ \text{mol dm}^{-3}$ solutions are arranged in order of **increasing** pH (lowest first), what is the correct order?

$$NH_3(aq),\quad NaOH(aq),\quad HCl(aq),\quad CH_3COOH(aq)$$

A. $NaOH, NH_3, CH_3COOH, HCl$

B. $HCl, CH_3COOH, NH_3, NaOH$

C. $HCl, CH_3COOH, NaOH, NH_3$

D. $NaOH, NH_3, HCl, CH_3COOH$

28. Consider a weak acid HA dissolved in water.

$$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$$

Which statements are correct?

I. $A^-(aq)$ is a much stronger base than $H_2O(l)$.

II. HA dissociates only to a very small extent in aqueous solution.

III. The concentration of $H_3O^+(aq)$ is much greater than the concentration of HA(aq).

A. I, II and III

B. II and III only

C. I and II only

D. I and III only

29. When the following aqueous solutions are arranged in order of **increasing** electrical conductivity (lowest first), what is the correct order?

I. $0.10\ mol\ dm^{-3}\ CH_3COOH$

II. $0.10\ mol\ dm^{-3}\ CH_3CH_2OH$

III. $0.10\ mol\ dm^{-3}\ CH_3COONa$

A. I, II, III

B. III, II, I

C. I, III, II

D. II, I, III

30. A certain buffer solution contains equal concentrations of $X^-(aq)$ and $HX(aq)$. The K_b value for $X^-(aq)$ is 1.0×10^{-10}. What is the pH of the buffer?

A. 1

B. 4

C. 5

D. 10

31. In the reaction

$$3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$$

A. Br_2 is only oxidised.

B. Br_2 is only reduced.

C. Br_2 is neither oxidised nor reduced.

D. Br_2 is both oxidised and reduced.

32. Consider the following statements regarding electrolysis of molten lead(II) bromide.

I. Oxidation takes place at the anode where lead ions gain electrons.
II Reduction takes place at the cathode where lead ions gain electrons.
III Oxidation takes place at the anode where bromide ions lose electrons.
IV. Reduction takes place at the cathode where bromide ions lose electrons.

Which of the above statements are correct?

A. I and II only

B. I and IV only

C. II and III only

D. II and IV only

33. The standard electrode potentials of three elements are as follows:

X	+1.09 V
Y	+0.54 V
Z	+1.36 V

Which statement is correct?

A. Z will oxidise $Y^-(aq)$ and $X^-(aq)$

B. Y will oxidise $X^-(aq)$ and $Z^-(aq)$

C. X will oxidise $Y^-(aq)$ and $Z^-(aq)$

D. Z will oxidise $Y^-(aq)$ but not $X^-(aq)$

34. One Faraday of electricity was passed through the electrolytic cells placed in series containing solutions of $Ag^+(aq)$, $Ni^{2+}(aq)$ and $Cr^{3+}(aq)$. What mass of Ag, Ni and Cr respectively will be deposited?
[A_r values: Ag = 108, Ni = 59, Cr = 52]

A. 36 g, 29.5 g and 52 g

B. 108 g, 59 g and 52 g

C. 108 g, 29.5 g and 17.3 g

D. 108 g, 118 g and 156 g

35. Consider the following reaction:

$$CH_3COOH + NH_3 \rightarrow CH_3COONH_4 \xrightarrow{\text{heat}} CH_3CONH_2$$

What will be the final product if aminoethane (ethylamine) is used instead of NH_3 ?

A. $CH_3CONHCH_2CH_3$

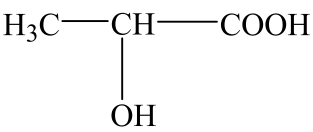
B. $CH_3CONHCH_3$

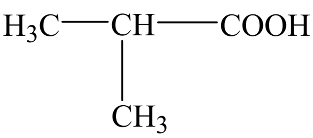
C. CH_3CONH_2

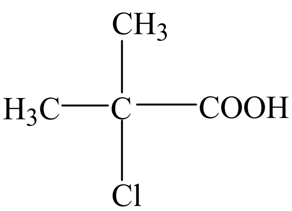
D. $CH_3CONH_2CH_2CH_3$

36. Which of the following compounds is optically active?

A. $HO—CH_2—COOH$

B. 

C. 

D. 

37. How many different environments for hydrogen atoms are present in the ^{1}H NMR spectrum of the following compound?

$$(CH_3)_2CHCH_2CH_3$$

A. 3

B. 4

C. 5

D. 9

38. Consider the following reactions:

$$CH_3CH_2CH_2OH \xleftarrow{\boxed{\text{I}}} CH_3CH_2\overset{\overset{\displaystyle O}{\|}}{C}—H \xrightarrow{\boxed{\text{II}}} CH_3CH_2\overset{\overset{\displaystyle O}{\|}}{C}—OH$$

What are reagents I and II respectively?

	I	II
A.	$H^+ / Cr_2O_7^{2-}(aq)$	$LiAlH_4$
B.	H_2/Ni	$LiAlH_4$
C.	$LiAlH_4$	$H^+ / Cr_2O_7^{2-}(aq)$
D.	$H^+/MnO_4^-(aq)$	$H^+ / Cr_2O_7^{2-}(aq)$

39. An organic liquid L has a relative molecular mass of 46. On heating with concentrated H_2SO_4 at 170 °C, a colourless gas is evolved which decolourises $Br_2(aq)$. What is the organic liquid L?

A. CH_3CH_2OH

B. CH_3OCH_3

C. $CH_3CH{=}CH_2$

D. CH_3OH

40. The alkaline hydrolysis of primary halogenoalkanes usually follows an S_N2 mechanism. For which compound would the rate of hydrolysis be fastest?

A. $CH_3CH_2CH_2F$

B. $CH_3CH_2CH_2Cl$

C. $CH_3CH_2CH_2Br$

D. $CH_3CH_2CH_2I$