IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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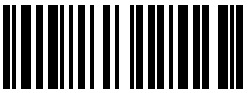
M06/4/CHEMI/HPM/ENG/TZ0/XX+



CHEMISTRY
HIGHER LEVEL
PAPER 1

Thursday 18 May 2006 (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. Which of the following quantities has units?

A. Relative atomic mass

B. Relative molecular mass

C. Molar mass

D. Mass number

2. A reaction occurring in the extraction of lead from its ore can be represented by this unbalanced equation:

$$\_\_\,PbS + \_\_\,O_2 \rightarrow \_\_\,PbO + \_\_\,SO_2$$

When the equation is balanced using the smallest possible whole numbers, what is the coefficient for O_2?

A. 1

B. 2

C. 3

D. 4

3. The equation for a reaction occurring in the synthesis of methanol is

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$

What is the maximum amount of methanol that can be formed from 2 mol of carbon dioxide and 3 mol of hydrogen?

A. 1 mol

B. 2 mol

C. 3 mol

D. 5 mol

4. How many neutrons are there in the ion $^{18}O^{2-}$?

A. 8

B. 10

C. 16

D. 20

5. What is the purpose of the beam of high energy electrons used in a mass spectrometer?

A. To ionize atoms

B. To accelerate ions

C. To deflect ions

D. To detect ions

6. Which statement is correct about electron orbitals and energy levels?

A. Yttrium, Y, (Z = 39) is the first element in the periodic table with an electron in a f sub-level.

B. The maximum number of electrons in one d orbital is 10.

C. The maximum number of electrons in the 4th main energy level is 18.

D. In a main energy level, the sub-level with the highest energy is labelled f.

7. Which is correct about the element tin (Sn) (Z = 50)?

	Number of main energy levels containing electrons	Number of electrons in highest main energy level
A.	4	4
B.	4	14
C.	5	4
D.	5	14

8. Which reaction results in the formation of a coloured substance?

A. $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$

B. $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

C. $Cl_2(g) + 2NaI(aq) \rightarrow 2NaCl(aq) + I_2(s)$

D. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

9. Which compound of an element in period 3 reacts with water to form a solution with a pH greater than 7?

A. SiO_2

B. $SiCl_4$

C. NaCl

D. Na_2O

10. Which electrons are lost by an atom of iron when it forms the Fe^{3+} ion?

A. One s orbital electron and two d orbital electrons

B. Two s orbital electrons and one d orbital electron

C. Three s orbital electrons

D. Three d orbital electrons

11. Which statement is a correct description of electron loss in this reaction?

$$2Al + 3S \rightarrow Al_2S_3$$

A. Each aluminium atom loses two electrons.

B. Each aluminium atom loses three electrons.

C. Each sulfur atom loses two electrons.

D. Each sulfur atom loses three electrons.

12. In which substance is hydrogen bonding present?

A. CH_4

B. CH_2F_2

C. CH_3CHO

D. CH_3OH

13. Which is the most volatile substance?

A. Chlorine

B. Fluorine

C. Sodium chloride

D. Sodium fluoride

14. Which is the smallest bond angle in the PF_5 molecule?

A. 90°

B. 109.5°

C. 120°

D. 180°

15. Which types of hybridization are shown by the carbon atoms in the compound $CH_2 = CH - CH_3$?

I. sp
II. sp^2
III. sp^3

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

16. A cylinder of gas is at a pressure of 40 kPa. The volume and temperature (in K) are both doubled. What is the pressure of the gas after these changes?

A. 10 kPa

B. 20 kPa

C. 40 kPa

D. 80 kPa

17. The equations and enthalpy changes for two reactions used in the manufacture of sulfuric acid are:

$$S(s) + O_2(g) \rightarrow SO_2(g) \quad \Delta H^{\ominus} = -300 \text{ kJ}$$
$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \quad \Delta H^{\ominus} = -200 \text{ kJ}$$

What is the enthalpy change, in kJ, for the reaction below?

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

A. –100

B. –400

C. –500

D. –800

18. Which reaction has the largest positive value of $\Delta S^{\ominus}$?

A. $CO_2(g) + 3H_2(g) \rightarrow CH_3OH(g) + H_2O(g)$

B. $2Al(s) + 3S(s) \rightarrow Al_2S_3(s)$

C. $CH_4(g) + H_2O(g) \rightarrow 3H_2(g) + CO(g)$

D. $2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$

19. Approximate values of the average bond enthalpies, in kJ mol^{-1}, of three substances are:

H–H	430
F–F	155
H–F	565

What is the enthalpy change, in kJ, for this reaction?

$$2HF \rightarrow H_2 + F_2$$

A. +545

B. +20

C. –20

D. –545

20. The standard enthalpy change of formation values of two oxides of phosphorus are:

$$P_4(s) + 3O_2(g) \rightarrow P_4O_6(s) \qquad \Delta H^{\ominus}_f = -1600 \text{ kJ mol}^{-1}$$
$$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s) \qquad \Delta H^{\ominus}_f = -3000 \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for the reaction below?

$$P_4O_6(s) + 2O_2(g) \rightarrow P_4O_{10}(s)$$

A. +4600

B. +1400

C. –1400

D. –4600

21. Which is a correct equation to represent the lattice enthalpy of magnesium sulfide?

A. $MgS(s) \rightarrow Mg(s) + S(s)$

B. $MgS(s) \rightarrow Mg(g) + S(g)$

C. $MgS(s) \rightarrow Mg^{+}(g) + S^{-}(g)$

D. $MgS(s) \rightarrow Mg^{2+}(g) + S^{2-}(g)$

22. A reaction occurs in four steps. The steps and their rates are shown in the table

Step	Rate
1	$0.01\ mol\ dm^{-3} s^{-1}$
2	$0.10\ mol\ dm^{-3} s^{-1}$
3	$0.01\ mol\ dm^{-3}\ min^{-1}$
4	$0.10\ mol\ dm^{-3}\ min^{-1}$

Which is the rate-determining step?

A. Step 1

B. Step 2

C. Step 3

D. Step 4

23. The rate expression for a reaction is

$$rate = k[CH_3Br][OH^-]$$

Which is a possible unit for k?

A. $mol^2\ dm^{-6}\ min^{-1}$

B. $mol\ dm^{-3}\ min^{-1}$

C. $mol^{-1}\ dm^3\ min^{-1}$

D. $mol^{-2}\ dm^6\ min^{-1}$

24. What happens to the rate constant (k) and activation energy (E_a) of a reaction when the temperature is increased?

A. k increases and E_a is unaffected.

B. k decreases and E_a is unaffected.

C. E_a increases and k is unaffected.

D. E_a decreases and k is unaffected.

25. The equation for a reversible reaction used in industry to convert methane to hydrogen is shown below.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +210 \text{ kJ}$$

Which statement is always correct about this reaction when equilibrium has been reached?

A. The concentrations of methane and carbon monoxide are equal.

B. The rate of the forward reaction is greater than the rate of the reverse reaction.

C. The amount of hydrogen is three times the amount of methane.

D. The value of $\Delta H^{\ominus}$ for the reverse reaction is –210 kJ.

26. The expression for the equilibrium constant for a reaction is

$$K_c = \frac{[B][C]}{[A]^2}$$

At a certain temperature the values of [A], [B] and [C] are all 0.2 mol dm^{-3}. What happens to the value of K_c when all three values are doubled to 0.4 mol dm^{-3}?

A. It is halved.

B. It does not change.

C. It doubles.

D. It increases by a factor of four.

27. The strengths of organic acids can be compared using K_a and pK_a values. Which acid is the strongest?

A.	Acid A	$pK_a = 6$
B.	Acid B	$pK_a = 3$
C.	Acid C	$K_a = 1 \times 10^{-5}$
D.	Acid D	$K_a = 1 \times 10^{-4}$

28. Which methods can distinguish between solutions of a strong monoprotic acid and a weak monoprotic acid of the same concentration?

I. Add magnesium to each solution and measure the rate of the formation of gas bubbles.
II. Add aqueous sodium hydroxide to each solution and measure the temperature change.
III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. Which species are a conjugate pair according to the Brønsted-Lowry theory?

A. CH_3COOH and CH_3CHO

B. NH_3 and BF_3

C. $H_2NO_3^+$ and NO_3^-

D. H_2SO_4 and HSO_4^-

30. Which is the correct statement about the pH and pOH values of an aqueous solution at 25 °C?

A. $\mathrm{pH} + \mathrm{pOH} = 14.0$

B. $\mathrm{pH} + \mathrm{pOH} = 1.0 \times 10^{-14}$

C. $\mathrm{pH} \times \mathrm{pOH} = 14.0$

D. $\mathrm{pH} \times \mathrm{pOH} = 1.0 \times 10^{-14}$

31. Which salt, when dissolved in water to form a $1.0\ \mathrm{mol\ dm^{-3}}$ solution, produces the lowest pH value?

A. Ammonium chloride

B. Ammonium ethanoate

C. Sodium ethanoate

D. Sodium chloride

32. A voltaic cell is made from magnesium and iron half-cells. Magnesium is a more reactive metal than iron. Which statement is correct when the cell produces electricity?

A. Electrons are lost from magnesium atoms.

B. The concentration of $\mathrm{Fe^{2+}}$ ions increases.

C. Electrons flow from the iron half-cell to the magnesium half-cell.

D. Negative ions flow through the salt bridge from the magnesium half-cell to the iron half-cell.

33. A metallic object is electroplated with copper using a solution of copper(II) sulfate. Which statement is correct?

A. The positive electrode increases in mass.

B. The concentration of $\mathrm{Cu^{2+}}$ ions in the solution decreases.

C. Reduction occurs at the positive electrode.

D. The reaction occurring at the negative electrode is $\mathrm{Cu^{2+} + 2e^- \rightarrow Cu}$.

34. Two half-equations and their standard electrode potentials are shown in the table.

Half-equation	$E^{\ominus}$ / V
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	–0.13
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80

What is the cell potential, in V, for the reaction below?

$$Pb(s) + 2Ag^+(aq) \rightarrow Pb^{2+}(aq) + 2Ag(s)$$

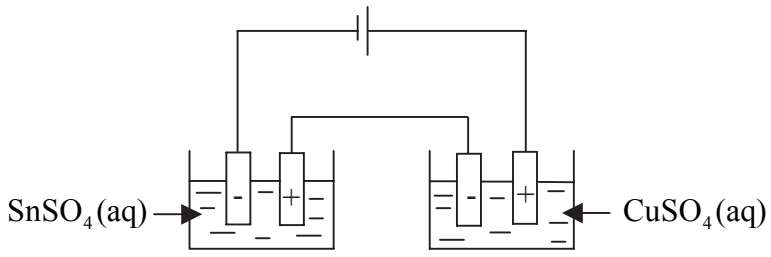
A. 0.67

B. 0.93

C. 1.47

D. 1.73

35. Two electrolytic cells are connected in series so that the same current flows through both cells for the same length of time.



The amount of tin deposited is 0.01 mol. How much copper is deposited?

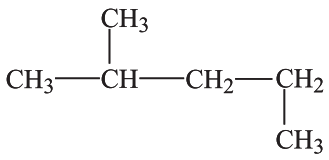
A. 0.005 mol

B. 0.01 mol

C. 0.02 mol

D. 0.05 mol

36. What is the correct name of this compound?



A. 1,3-dimethylbutane

B. 2,4-dimethylbutane

C. 2-methylbutane

D. 2-methylpentane

37. What is/are the product(s) of the reaction between ethene and hydrogen bromide?

A. CH_3CH_2Br

B. CH_3CH_2Br and H_2

C. CH_2BrCH_2Br

D. CH_2BrCH_2Br and H_2

38. How many peaks are there in the ^1H NMR spectrum of $(CH_3)_2CHCOCH_3$?

A. 2

B. 3

C. 4

D. 5

39. Which are characteristics typical of a free radical?

I. It has a lone pair of electrons.
II. It can be formed by the homolytic fission of a covalent bond.
III. It is uncharged.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. Which compound is formed by the dehydration of butan-2-ol, $CH_3CH(OH)CH_2CH_3$?

A. $CH_3CH_2CH_2CHO$

B. $CH_3COCH_2CH_3$

C. $CH_3CHCHCH_3$

D. $CH_3CH_2CH_2CH_3$