IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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M07/4/CHEMI/HPM/ENG/TZ0/XX

22076101

CHEMISTRY
HIGHER LEVEL
PAPER 1

Thursday 10 May 2007 (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

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. On complete combustion, a sample of a hydrocarbon compound produces 1.5 mol of carbon dioxide and 2.0 mol of water. What is the molecular formula of this hydrocarbon?

A. C_2H_2

B. C_2H_4

C. C_3H_4

D. C_3H_8

2. When excess $BaCl_2$(aq) was added to a sample of $Fe(NH_4)_2(SO_4)_2$(aq) to determine the amount in moles of sulfate present, 5.02×10^{-3} mol of $BaSO_4$ was obtained. How many moles of sulfate ions and iron ions were in the sample of $Fe(NH_4)_2(SO_4)_2$?

	Amount of sulfate ions / moles	Amount of iron ions / moles
A.	5.02×10^{-3}	2.51×10^{-3}
B.	10.04×10^{-3}	5.02×10^{-3}
C.	2.51×10^{-3}	5.02×10^{-3}
D.	10.04×10^{-3}	2.51×10^{-3}

3. What volume of 0.500 mol dm^{-3} sulfuric acid solution is required to react completely with 10.0 g of calcium carbonate according to the equation below?

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2O(l) + CO_2(g)$$

A. 100 cm^3

B. 200 cm^3

C. 300 cm^3

D. 400 cm^3

4. A transition metal ion X^{2+} has the electronic configuration $[Ar]3d^9$. What is the atomic number of the element?

A. 27

B. 28

C. 29

D. 30

5. Which statements are correct for the emission spectrum of the hydrogen atom?

I. The lines converge at lower energies.
II. Electron transitions to $n = 1$ are responsible for lines in the UV region.
III. Lines are produced when electrons move from higher to lower energy levels.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

6. Which statement is correct for the halogen group?

A. Halide ions are all reducing agents, with iodide ions being the weakest.

B. Halogens are all oxidizing agents, with chlorine being the strongest.

C. Chloride ions can be oxidized to chlorine by bromine.

D. Iodide ions can be oxidized to iodine by chlorine.

7. Which of the following statements are correct?

I. The melting points decrease from Li → Cs for the alkali metals.
II. The melting points increase from F → I for the halogens.
III. The melting points decrease from Na → Ar for the period 3 elements.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. The compound $[Co(NH_3)_5Br]SO_4$ is isomeric with the compound $[Co(NH_3)_5SO_4]Br$. What is the oxidation state of cobalt in these compounds?

	$[Co(NH_3)_5Br]SO_4$	$[Co(NH_3)_5SO_4]Br$
A.	+3	+3
B.	+2	+1
C.	+3	+2
D.	+2	+3

9. When C_2H_4, C_2H_2 and C_2H_6 are arranged in order of **increasing** C–C bond length, what is the correct order?

A. C_2H_6, C_2H_2, C_2H_4

B. C_2H_4, C_2H_2, C_2H_6

C. C_2H_2, C_2H_4, C_2H_6

D. C_2H_4, C_2H_6, C_2H_2

10. Which compound contains **both** ionic and covalent bonds?

A. $MgCl_2$

B. HCl

C. H_2CO

D. NH_4Cl

11. When the species BF_2^+, BF_3 and BF_4^- are arranged in order of **increasing** F – B – F bond angle, what is the correct order?

A. BF_3, BF_4^-, BF_2^+

B. BF_4^-, BF_3, BF_2^+

C. BF_2^+, BF_4^-, BF_3

D. BF_2^+, BF_3, BF_4^-

12. Which molecule is square planar in shape?

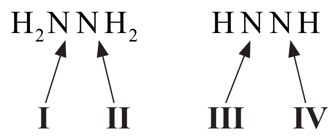
A. XeO_4

B. XeF_4

C. SF_4

D. SiF_4

13. What is the hybridization of nitrogen atoms I, II, III and IV in the following molecules?



	I	II	III	IV
A.	sp^2	sp^2	sp^3	sp^3
B.	sp^3	sp^3	sp^2	sp^2
C.	sp^2	sp^2	sp	sp
D.	sp^3	sp^3	sp	sp

14. 1 mole of hydrogen, 2 moles of oxygen and 3 moles of carbon dioxide are placed in a closed container at 298 K. What is the ratio of **average** kinetic energies of each gas under these conditions?

A. 1 : 2 : 3

B. 3 : 2 : 1

C. 1 : 1 : 1

D. 1 : 2 : 1

15. Consider the following reactions.

$$S(s) + 1\tfrac{1}{2}O_2(g) \rightarrow SO_3(g) \qquad \Delta H^{\ominus} = -395 \text{ kJ mol}^{-1}$$

$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightarrow SO_3(g) \qquad \Delta H^{\ominus} = -98 \text{ kJ mol}^{-1}$$

What is the $\Delta H^{\ominus}$ value (in kJ mol^{-1}) for the following reaction?

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

A. –297

B. +297

C. –493

D. +493

16. Which statement is correct for an endothermic reaction?

A. Bonds in the products are stronger than the bonds in the reactants.

B. Bonds in the reactants are stronger than the bonds in the products.

C. The enthalpy of the products is less than that of the reactants.

D. The reaction is spontaneous at low temperatures but becomes non-spontaneous at high temperatures.

17. Consider the following information.

Compound	$C_6H_6(l)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	+49	–394	–286

$$C_6H_6(l) + 7\tfrac{1}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$$

Which expression gives the correct value of the standard enthalpy change of combustion for benzene (l), in kJ mol^{-1}?

A. $12(-394) + 6(-286) - 2(49)$

B. $12(394) + 6(286) - 2(-49)$

C. $6(-394) + 3(-286) - (49)$

D. $6(394) + 3(286) - (-49)$

18. Which equation represents the lattice enthalpy of magnesium oxide?

A. $Mg(s) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s)$

B. $Mg^{2+}(g) + O^{2-}(g) \rightarrow MgO(g)$

C. $Mg^{2+}(g) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s)$

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

19. At 25 °C, 100 cm^3 of 1.0 mol dm^{-3} hydrochloric acid is added to 3.5 g of magnesium carbonate. If the sample of magnesium carbonate is kept constant, which conditions will **not** increase the initial rate of reaction?

	Volume of HCl / cm^3	Concentration of HCl / mol dm^{-3}	Temperature / °C
A.	200	1.0	25
B.	100	2.0	25
C.	100	1.0	35
D.	200	2.0	25

20. Consider the reaction

$$2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

In the presence of $S_2O_3^{2-}(aq)$ and starch solution, the time taken for a blue colour to form was observed at various reactant concentrations.

Experiment	$[I^-]$ / mol dm^{-3}	$[H_2O_2]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	Time / s
1	0.10	0.12	0.01	25
2	0.05	0.12	0.01	50
3	0.10	0.06	0.01	100

What is the correct order with respect to I^- and H_2O_2?

	I^-	H_2O_2
A.	1	2
B.	$\frac{1}{2}$	$\frac{1}{4}$
C.	2	1
D.	2	4

21. Which statement is correct with regard to the catalysed and uncatalysed pathways for a given reaction?

A. The enthalpy change of the catalysed reaction is less than the enthalpy change for the uncatalysed reaction.

B. The enthalpy change of the catalysed reaction is greater than the enthalpy change for the uncatalysed reaction.

C. The enthalpy change of the catalysed reaction is equal to the enthalpy change for the uncatalysed reaction.

D. The activation energy of the catalysed reaction is greater than the activation energy for the uncatalysed reaction.

22. Consider the following equilibrium reaction in a closed container at 350 °C.

$$SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g) \qquad \Delta H^{\ominus} = -85 \text{ kJ}$$

Which statement is correct?

A. Decreasing the temperature will increase the amount of $SO_2Cl_2(g)$.

B. Increasing the volume of the container will increase the amount of $SO_2Cl_2(g)$.

C. Increasing the temperature will increase the amount of $SO_2Cl_2(g)$.

D. Adding a catalyst will increase the amount of $SO_2Cl_2(g)$.

23. A 1.0 dm^3 reaction vessel initially contains 6.0 mol of **P** and 6.0 mol of **Q**. At equilibrium 4.0 mol of **R** is present. What is the value of K_c for the following reaction?

$$P(g) + Q(g) \rightleftharpoons R(g) + S(g)$$

A. 0.11

B. 0.25

C. 0.44

D. 4.00

24. Solutions of hydrochloric acid ($HCl\,(aq)$) and ethanoic acid ($CH_3COOH\,(aq)$) of the same concentration reacted completely with 5.0 g of calcium carbonate in separate containers. Which statement is correct?

A. $CH_3COOH\,(aq)$ reacted slower because it has a lower pH than $HCl\,(aq)$.

B. A smaller volume of $CO_2\,(g)$ was produced with $CH_3COOH\,(aq)$ than with $HCl(aq)$.

C. A greater volume of $CO_2\,(g)$ was produced with $CH_3COOH\,(aq)$ than with $HCl(aq)$.

D. The same volume of $CO_2\,(g)$ was produced with both $CH_3COOH\,(aq)$ and $HCl(aq)$.

25. Ammonia (NH_3) is a weak base in aqueous solution with an ionization constant K_b. What expression is equal to the ionization constant for the following reaction?

$$NH_4^+(aq) + H_2O\,(l) \rightleftharpoons NH_3\,(aq) + H_3O^+(aq)$$

A. $\dfrac{K_w}{K_a}$

B. $\dfrac{K_a}{K_w}$

C. $\dfrac{K_w}{K_b}$

D. $\dfrac{K_b}{K_w}$

26. The pK_a values of four acids are as follows.

W	4.87
X	4.82
Y	4.86
Z	4.85

What is the correct order when these acids are arranged in order of **increasing** acid strength?

A. X, Z, Y, W

B. X, Y, Z, W

C. W, Z, Y, X

D. W, Y, Z, X

27. 10 cm^3 of 0.01 mol dm^{-3} nitric acid (HNO_3) is diluted with 90 cm^3 of water. What is the pH of the resulting solution?

A. 1

B. 2

C. 3

D. 4

28. A base of concentration 0.10 mol dm^{-3} is titrated with 25 cm^3 of an acid of concentration 0.10 mol dm^{-3}. Which base-acid pair would have the highest pH at the equivalence point?

A. NaOH (aq) and CH_3COOH (aq)

B. NaOH (aq) and HNO_3 (aq)

C. NH_3 (aq) and HNO_3 (aq)

D. NH_3 (aq) and CH_3COOH (aq)

29. Consider the following spontaneous reactions.

$$\mathrm{Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)}$$
$$\mathrm{Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)}$$
$$\mathrm{Zn(s) + Fe^{2+}(aq) \rightarrow Zn^{2+}(aq) + Fe(s)}$$

Which is the correct combination of strongest oxidizing agent and strongest reducing agent?

	Strongest oxidizing agent	Strongest reducing agent
A.	Ag(s)	Zn(s)
B.	Ag^{+}(aq)	Zn(s)
C.	Zn^{2+}(aq)	Ag(s)
D.	Zn(s)	Ag^{+}(aq)

30. Which statement is correct?

A. Spontaneous redox reactions produce electricity in an electrolytic cell.

B. Electricity is used to carry out a non-spontaneous redox reaction in a voltaic cell.

C. Oxidation takes place at the negative electrode in a voltaic cell and the positive electrode in an electrolytic cell.

D. Oxidation takes place at the negative electrode in a voltaic cell and reduction takes place at the positive electrode in an electrolytic cell.

31. Consider the standard electrode potentials of the following reactions:

$$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq) \qquad +0.15\text{V}$$
$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad +0.77\text{V}$$

What is the value of the cell potential (in volts) for the spontaneous reaction?

A. +1.69

B. +1.39

C. +0.92

D. +0.62

32. In the electrolysis of acidified water, if 8.4 cm^3 of hydrogen gas is evolved, what volume of oxygen gas is evolved?

A. 4.2 cm^3

B. 8.4 cm^3

C. 12.6 cm^3

D. 16.8 cm^3

33. Which factors affect the amount of metal formed during electrolysis?

I. Charge on the metal ion
II. Current
III. Time

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

34. Nylon is a condensation polymer made up of hexanedioic acid and 1,6-diaminohexane. Which type of linkage is present in nylon?

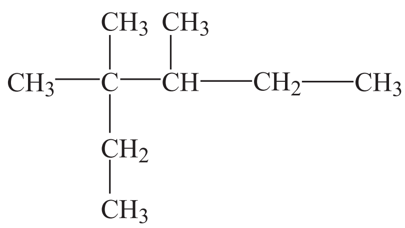
A. Amide

B. Ester

C. Amine

D. Carboxyl

35. What is the IUPAC name of the following compound?



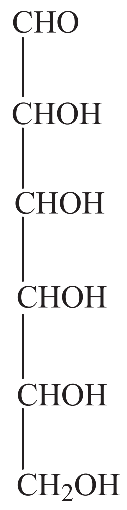
A. 3,3,4-trimethylhexane

B. 3,4,4-trimethylhexane

C. 4-ethyl-3,4-dimethylpentane

D. 2-ethyl-2,3-dimethylpentane

36. How many chiral carbon atoms are present in a molecule of glucose?



A. 1

B. 2

C. 3

D. 4

37. An organic compound **X** reacts with excess acidified potassium dichromate(VI) to form compound **Y**, which reacts with sodium carbonate to produce CO_2(g).

What is a possible formula for compound **X**?

A. CH_3CH_2COOH

B. $CH_3CH_2CH_2OH$

C. $CH_3CH(OH)CH_3$

D. $(CH_3)_3COH$

38. What is the ratio of peak areas in the ^{1}H NMR spectrum of the following compound?

$$CH_3CH(CH_3)CH_2CH_3$$

A. 3 : 1 : 3 : 2 : 3

B. 3 : 2 : 3 : 1 : 3

C. 3 : 1 : 3 : 5

D. 6 : 1 : 2 : 3

39. Which statement is correct with regard to a nucleophilic substitution reaction?

A. Tertiary halogenoalkanes react slower than primary halogenoalkanes.

B. The rate of hydrolysis is faster for $CH_3CH_2CH_2Cl$ than for $CH_3CH_2CH_2I$.

C. Doubling the concentration of OH^- doubles the rate of the S_N2 reaction but not the S_N1 reaction.

D. Primary halogenoalkanes usually follow an S_N1 mechanism while tertiary halogenoalkanes follow an S_N2 mechanism.

40. The mass spectrum of a molecule C_3H_6O shows major peaks at *m/z* values of 58, 43 and 15. Which is the most likely structural formula of this compound?

A. CH_3CH_2CHO

B. CH_3COCH_3

C. $CH_3CH_2OCH_3$

D. $CH_3CH_2CH_2OH$