

Chemistry HL P1

2007 November

School Level 12th IB Diploma

Programme

Board Exam

International Baccalaureate (IB

Board)

Solved



**CHEMISTRY  
HIGHER LEVEL  
PAPER 1**

Wednesday 14 November 2007 (afternoon)

1 hour

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**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

		Atomic Number															
		Element															
		Atomic Mass															
1	2	3	4	5	6	7	8	9	10								
1 <b>H</b> 1.01									2 <b>He</b> 4.00								
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01							9 <b>F</b> 19.00	10 <b>Ne</b> 20.18								
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31							17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95								
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.71	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.37	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> 98.91	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.40	49 <b>In</b> 114.82	50 <b>Sn</b> 118.69	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.30
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.34	57 † <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.21	76 <b>Os</b> 190.21	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.09	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.37	82 <b>Pb</b> 207.19	83 <b>Bi</b> 208.98	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 † <b>Ac</b> (227)															

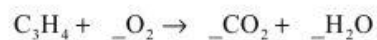
		†											
58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> 146.92	62 <b>Sm</b> 150.35	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.92	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97

		‡											
90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

1. Which expression gives the amount (in mol) of a substance, if the mass is given in grams?
- A.  $\frac{\text{mass}}{\text{molar mass}}$
- B.  $\frac{\text{molar mass}}{\text{mass}}$
- C.  $\frac{1}{\text{molar mass}}$
- D.  $\text{mass} \times \text{molar mass}$
2. What is the total number of atoms in 0.20 mol of propanone,  $\text{CH}_3\text{COCH}_3$ ?
- A.  $1.2 \times 10^{22}$
- B.  $6.0 \times 10^{23}$
- C.  $1.2 \times 10^{24}$
- D.  $6.0 \times 10^{24}$
3. Ethyne,  $\text{C}_2\text{H}_2$ , reacts with oxygen according to the equation below. What volume of oxygen (in  $\text{dm}^3$ ) reacts with  $0.40 \text{ dm}^3$  of  $\text{C}_2\text{H}_2$ ?
- $$2\text{C}_2\text{H}_2(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$
- A. 0.40
- B. 0.80
- C. 1.0
- D. 2.0

4. When the equation below is balanced for 1 mol of  $C_3H_4$ , what is the coefficient for  $O_2$ ?



- A. 2  
B. 3  
C. 4  
D. 5
5. How many orbitals are there in the  $n = 3$  level of an atom?  
A. 3  
B. 5  
C. 7  
D. 9
6. When Na, K, and Mg are arranged in **increasing** order of atomic radius (smallest first), which order is correct?  
A. Na, K, Mg  
B. Na, Mg, K  
C. K, Mg, Na  
D. Mg, Na, K
7. Which element is a transition metal?  
A. Ca  
B. Cr  
C. Ge  
D. Se

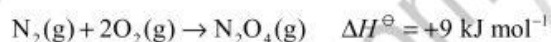
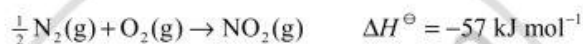
8. Which oxides produce an acidic solution when added to water?
- I.  $\text{SiO}_2$
  - II.  $\text{P}_4\text{O}_6$
  - III.  $\text{SO}_2$
- A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
9. What is the formula for an ionic compound formed between an element, X, from group 2 and an element, Y, from group 6?
- A. XY
  - B.  $\text{X}_2\text{Y}$
  - C.  $\text{XY}_2$
  - D.  $\text{X}_2\text{Y}_6$
10. What is the shape of the  $\text{CO}_3^{2-}$  ion and the approximate O-C-O bond angle?
- A. Linear,  $180^\circ$
  - B. Trigonal planar,  $90^\circ$
  - C. Trigonal planar,  $120^\circ$
  - D. Pyramidal,  $109^\circ$

11. In the molecules  $\text{N}_2\text{H}_4$ ,  $\text{N}_2\text{H}_2$ , and  $\text{N}_2$ , the nitrogen atoms are linked by single, double and triple bonds, respectively. When these molecules are arranged in increasing order of the lengths of their nitrogen to nitrogen bonds (shortest bond first) which order is correct?
- A.  $\text{N}_2\text{H}_4$ ,  $\text{N}_2$ ,  $\text{N}_2\text{H}_2$
- B.  $\text{N}_2\text{H}_4$ ,  $\text{N}_2\text{H}_2$ ,  $\text{N}_2$
- C.  $\text{N}_2\text{H}_2$ ,  $\text{N}_2$ ,  $\text{N}_2\text{H}_4$
- D.  $\text{N}_2$ ,  $\text{N}_2\text{H}_2$ ,  $\text{N}_2\text{H}_4$
12. What is the molecular geometry and the Cl-I-Cl bond angle in the  $\text{ICl}_4^-$  ion?
- A. Square planar  $90^\circ$
- B. Square pyramidal  $90^\circ$
- C. Tetrahedral  $109^\circ$
- D. Trigonal pyramidal  $107^\circ$
13. What is the geometry of the bonds around an atom with  $\text{sp}^2$  hybridization?
- A. 2 bonds at  $180^\circ$
- B. 3 bonds at  $120^\circ$
- C. 2 bonds at  $90^\circ$ , 1 bond at  $180^\circ$
- D. 4 bonds at  $109^\circ$
14. What will happen to the volume of a fixed mass of gas if the pressure and the Kelvin temperature are both doubled?
- A. It will remain the same.
- B. It will be double its initial volume.
- C. It will be one-half its initial volume.
- D. It will be four times its initial volume.

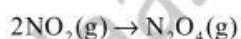
15. When 40 joules of heat are added to a sample of solid  $\text{H}_2\text{O}$  at  $-16.0^\circ\text{C}$  the temperature increases to  $-8.0^\circ\text{C}$ . What is the mass of the solid  $\text{H}_2\text{O}$  sample?

[Specific heat capacity of  $\text{H}_2\text{O}(\text{s}) = 2.0 \text{ J g}^{-1} \text{ K}^{-1}$ ]

- A. 2.5 g  
B. 5.0 g  
C. 10 g  
D. 160 g
16. The  $\Delta H^\ominus$  values for the formation of two oxides of nitrogen are given below.



Use these values to calculate  $\Delta H^\ominus$  (in kJ) for the following reaction



- A. -105  
B. -48  
C. +66  
D. +123
17. The  $\Delta H^\ominus$  and  $\Delta S^\ominus$  values for a reaction are both negative. What will happen to the spontaneity of this reaction as the temperature is increased?
- A. The reaction will become more spontaneous as the temperature is increased.  
B. The reaction will become less spontaneous as the temperature is increased.  
C. The reaction will remain spontaneous at all temperatures.  
D. The reaction will remain non-spontaneous at any temperature.



18. Which combination of ion charge and ion size produces the greatest lattice enthalpy?

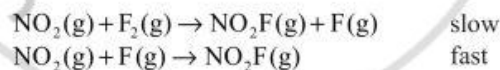
- A. High charge, large size
- B. High charge, small size
- C. Low charge, small size
- D. Low charge, large size

19. Which changes increase the rate of a chemical reaction?

- I. increase in the concentration of an aqueous solution
- II. increase in particle size of the same mass of a solid reactant
- III. increase in the temperature of the reaction mixture

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

20. For the reaction  $2\text{NO}_2(\text{g}) + \text{F}_2(\text{g}) \rightarrow 2\text{NO}_2\text{F}(\text{g})$  the accepted mechanism is



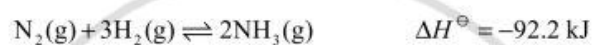
What is the rate expression for this reaction?

- A.  $\text{rate} = k[\text{NO}_2]^2[\text{F}_2]$
- B.  $\text{rate} = k[\text{NO}_2][\text{F}_2]$
- C.  $\text{rate} = k[\text{NO}_2][\text{F}]$
- D.  $\text{rate} = k[\text{NO}_2]^2$

21. The activation energy, of a reaction can be obtained from the rate constant,  $k$ , and the absolute temperature,  $T$ . Which graph of these quantities produces a straight line?

- A.  $k$  against  $T$
- B.  $k$  against  $\frac{1}{T}$
- C.  $\ln k$  against  $T$
- D.  $\ln k$  against  $\frac{1}{T}$

22. The equation for the Haber process is:



Which conditions will favour the production of the greatest amount of ammonia at equilibrium?

- A. High temperature and high pressure
  - B. High temperature and low pressure
  - C. Low temperature and high pressure
  - D. Low temperature and low pressure
23. Which combination of  $\Delta H_{\text{vaporization}}$  and boiling point is the result of strong intermolecular forces?

	$\Delta H_{\text{vaporization}}$	Boiling Point
A.	large	high
B.	large	low
C.	small	low
D.	small	high

24. The pH of a solution changes from pH = 1 to pH = 3. What happens to the  $[H^+]$  during this pH change?
- A. It increases by a factor of 100.
  - B. It decreases by a factor of 100.
  - C. It increases by a factor of 1000.
  - D. It decreases by a factor of 1000.
25. What is the conjugate base of the  $HSO_4^-(aq)$  ion?
- A.  $H_2SO_4(aq)$
  - B.  $SO_4^{2-}(aq)$
  - C.  $H_2O(l)$
  - D.  $H_3O^+(aq)$
26. What is the value of  $[H^+]$  in a buffer solution in which  $[CH_3COOH] = 2.0 \text{ mol dm}^{-3}$  and  $[CH_3COO^-] = 1.0 \text{ mol dm}^{-3}$ ? For  $CH_3COOH$ ,  $K_a = 1.8 \times 10^{-5} \text{ mol dm}^{-3}$ .
- A.  $6.0 \times 10^{-3}$
  - B.  $3.6 \times 10^{-5}$
  - C.  $1.8 \times 10^{-5}$
  - D.  $9.1 \times 10^{-6}$
27. Which salt forms the most acidic solution when added to water?
- A. NaCl
  - B.  $MgSO_4$
  - C.  $Al(NO_3)_3$
  - D.  $KHCO_3$

28. An acid-base indicator has a  $pK_a$  value of 4.0. At what pH will this indicator change colour?

- A. 2.0
- B. 4.0
- C. 8.0
- D. 12.0

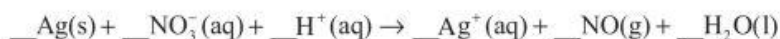
29. What happens to vanadium during the reaction  $\text{VO}^{2+}(\text{aq}) \rightarrow \text{VO}_3^-(\text{aq})$ ?

- A. It undergoes oxidation and its oxidation number changes from +4 to +5.
- B. It undergoes oxidation and its oxidation number changes from +2 to +4.
- C. It undergoes reduction and its oxidation number changes from +2 to -1.
- D. It undergoes reduction and its oxidation number changes from +4 to +2.

30. What occurs during the electrolysis of a molten salt?

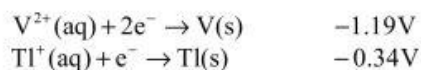
- A. Electricity is produced by a spontaneous redox reaction.
- B. Electricity is used to cause a non-spontaneous redox reaction to occur.
- C. Electrons flow through the molten salt.
- D. Electrons are removed from both ions of the molten salt.

31. What is the coefficient for  $\text{H}^+$  when the redox equation below is balanced?

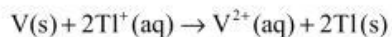


- A. 1
- B. 2
- C. 3
- D. 4

32. The standard electrode potentials for two half reactions are



What is the  $E^{\ominus}$  value (in volts) for the following reaction?



- A. +0.85  
B. +0.51  
C. -1.53  
D. -1.87
33. Which changes lead to the production of more moles of metal during the electrolysis of a molten salt?

- I. using a metal ion with a higher charge  
II. increasing the current  
III. using a longer time

- A. I and II only  
B. I and III only  
C. II and III only  
D. I, II and III

34. Which reactions can ethene undergo?

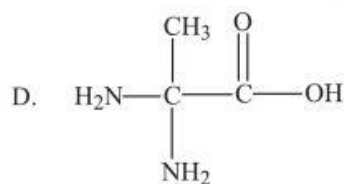
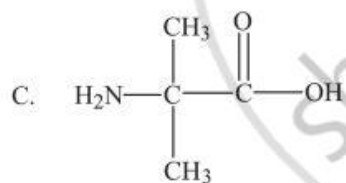
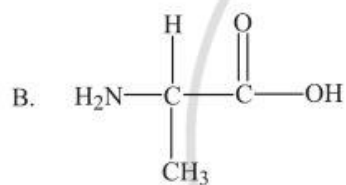
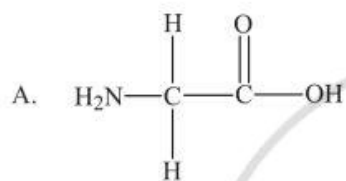
- I. addition  
II. esterification  
III. polymerization

- A. I and II only  
B. I and III only  
C. II and III only  
D. I, II and III

35. Which formula represents an aldehyde?

- A.  $\text{CH}_3\text{CH}_2\text{CHO}$
- B.  $\text{CH}_3\text{COCH}_3$
- C.  $\text{CH}_3\text{CH}_2\text{COOH}$
- D.  $\text{CH}_3\text{COOCH}_3$

36. Which amino acid can exist as optical isomers?



37. Which formula is consistent with a mass spectrum that includes a line at an  $m/z$  value of 15 but not 29?
- A.  $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$   
B.  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$   
C.  $\text{C}(\text{CH}_3)_4$   
D.  $\text{CH}_3(\text{CH}_2)_2\text{CHO}$
38. Which reactions does benzene undergo?
- I. combustion  
II. dehydration  
III. substitution
- A. I and II only  
B. I and III only  
C. II and III only  
D. I, II and III
39. Which combination of reactants shows the fastest reaction rate?
- A.  $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{F} + \text{OH}^-$   
B.  $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{Br} + \text{OH}^-$   
C.  $(\text{CH}_3)_3\text{CF} + \text{OH}^-$   
D.  $(\text{CH}_3)_3\text{CBr} + \text{OH}^-$
40. Which alcohol yields only one alkene when heated with concentrated  $\text{H}_2\text{SO}_4$ ?
- A.  $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$   
B.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$   
C.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$   
D.  $(\text{CH}_3\text{CH}_2)_2\text{C}(\text{OH})\text{CH}_3$

# **MARKSCHEME**

**November 2007**

**CHEMISTRY**

**Higher Level**

**Paper 1**

2 pages

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- |     |          |     |          |     |          |     |          |
|-----|----------|-----|----------|-----|----------|-----|----------|
| 1.  | <u>A</u> | 16. | <u>D</u> | 31. | <u>D</u> | 46. | <u>-</u> |
| 2.  | <u>C</u> | 17. | <u>B</u> | 32. | <u>A</u> | 47. | <u>-</u> |
| 3.  | <u>C</u> | 18. | <u>B</u> | 33. | <u>C</u> | 48. | <u>-</u> |
| 4.  | <u>C</u> | 19. | <u>B</u> | 34. | <u>B</u> | 49. | <u>-</u> |
| 5.  | <u>D</u> | 20. | <u>B</u> | 35. | <u>A</u> | 50. | <u>-</u> |
| 6.  | <u>D</u> | 21. | <u>D</u> | 36. | <u>B</u> | 51. | <u>-</u> |
| 7.  | <u>B</u> | 22. | <u>C</u> | 37. | <u>C</u> | 52. | <u>-</u> |
| 8.  | <u>C</u> | 23. | <u>A</u> | 38. | <u>B</u> | 53. | <u>-</u> |
| 9.  | <u>A</u> | 24. | <u>B</u> | 39. | <u>D</u> | 54. | <u>-</u> |
| 10. | <u>C</u> | 25. | <u>B</u> | 40. | <u>C</u> | 55. | <u>-</u> |
| 11. | <u>D</u> | 26. | <u>B</u> | 41. | <u>-</u> | 56. | <u>-</u> |
| 12. | <u>A</u> | 27. | <u>C</u> | 42. | <u>-</u> | 57. | <u>-</u> |
| 13. | <u>B</u> | 28. | <u>B</u> | 43. | <u>-</u> | 58. | <u>-</u> |
| 14. | <u>A</u> | 29. | <u>A</u> | 44. | <u>-</u> | 59. | <u>-</u> |
| 15. | <u>A</u> | 30. | <u>B</u> | 45. | <u>-</u> | 60. | <u>-</u> |