INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 7 November 2000 (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

1 **H** 1.01				Atomic Number 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)	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. Which compound has the highest percentage by mass of carbon?

A. C_2H_2

B. C_2H_4

C. C_3H_8

D. C_4H_{10}

2. A certain compound has a relative molar mass of 88. A possible empirical formula for this compound is

A. CH_2

B. CH_2O

C. CH_3O

D. C_2H_4O

3. $$H_2 + Cl_2 \rightarrow 2HCl$$

Hydrogen and chlorine react according to the equation above. What will be the result of the reaction of 2.0 moles of H_2 and 1.5 moles of Cl_2?

A. 3.5 mol of HCl

B. 1.5 mol of HCl and 0.5 mol of H_2

C. 2.0 mol of HCl and 0.5 mol of Cl_2

D. 3.0 mol of HCl and 0.5 mol of H_2

4. 25.0 cm^3 of sulfuric acid solution reacts with 36.2 cm^3 of 0.225 $mol\,dm^{-3}$ sodium hydroxide solution. The concentration of the acid is

A. $\dfrac{36.2 \times 0.225}{25.0}$

B. $\dfrac{2 \times 36.2 \times 0.225}{25.0}$

C. $\dfrac{36.2 \times 0.225}{2 \times 25.0}$

D. $\dfrac{25.0}{2 \times 36.2 \times 0.225}$

5. The electron transition between which two levels **releases** the most energy?

A. First to third

B. Fourth to ninth

C. Sixth to third

D. Second to first

6. A solid element, X, contains unpaired electrons in its atoms and forms an ionic chloride, XCl_2. Which electron configuration is possible for element X?

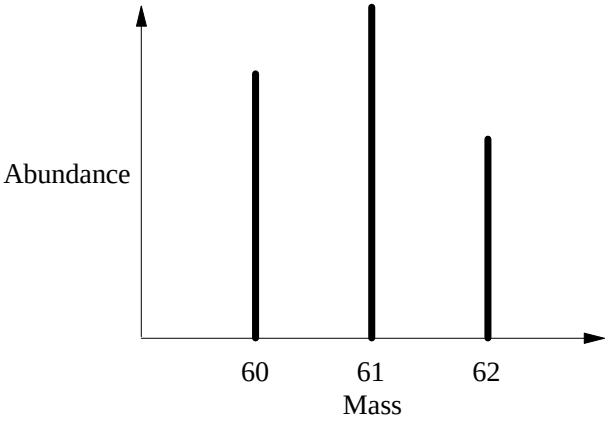
A. $[Ne]\,3s^2$

B. $[Ar]\,3d^2\,4s^2$

C. $[He]\,2s^2\,2p^2$

D. $[Ne]\,3s^2\,3p^4$

7.



The mass spectrum of an element is shown above. Which statement about this element is correct?

A. The three isotopes are separated after being converted to negative ions

B. The isotope with mass 62 will be deflected more than the isotopes with masses 60 or 61

C. The most abundant isotope contains 61 neutrons

D. Its atomic mass will be between 60 and 61

8. Which pair of species is listed in **increasing** order of the property given?

A. Ionisation energy: O, F

B. Radius: Mg, Mg^{2+}

C. Melting point: I_2, Br_2

D. Covalent character: HI, HBr

9. Most of the oxides of non-metallic elements are

A. ionic and basic.

B. ionic and acidic.

C. covalent and basic.

D. covalent and acidic.

10. Which aqueous complex ion will **not** be coloured?

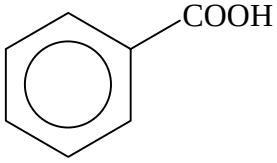
A. Ni^{2+}

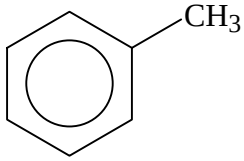
B. Fe^{2+}

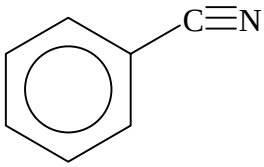
C. Sc^{3+}

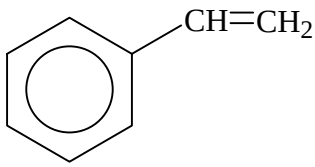
D. Cr^{3+}

11. Which compound contains both sp^2 and sp^3 hybridised carbon atoms?

A. 

C. 

B. 

D. 

12. Which molecule has the largest bond angle?

A. BF_3

B. CF_4

C. NF_3

D. OF_2

13. In which of the compounds below are the electrons in the carbon–oxygen bonds delocalised?

I. Sodium ethoxide, CH_3CH_2ONa

II. Sodium ethanoate, CH_3COONa

A. I only

B. II only

C. Both I and II

D. Neither I nor II

14. Which species does **not** contain at least one 90° bond angle?

A. CF_4

B. PF_5

C. SF_6

D. SiF_6^{2-}

15. Which compound has the **greatest** vapour pressure at 298 K?

A. C_3H_7OH

B. $C_2H_5OCH_3$

C. C_2H_5COOH

D. $C_3H_7NH_2$

16. 125 cm^3 of an unknown gas has a mass of 0.725 g at 25 °C and 0.97 atmospheres. Which expression will give the relative molar mass of the gas? ($R = 82.05\ cm^3\ atm\ K^{-1}\ mol^{-1}$)

A. $\dfrac{0.725 \times 82.05 \times 25}{0.97 \times 125}$

B. $\dfrac{125 \times 0.97}{0.725 \times 82.05 \times 298}$

C. $\dfrac{0.725 \times 82.05 \times 298}{0.97 \times 0.125}$

D. $\dfrac{0.725 \times 82.05 \times 298}{0.97 \times 125}$

17. For which combination of properties will a gas behave most ideally?

A. Polar molecules at a low temperature and high pressure

B. Polar molecules at a high temperature and low pressure

C. Nonpolar molecules at a low temperature and high pressure

D. Nonpolar molecules at a high temperature and low pressure

18.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ddot{o}} = -393\ kJ$$
$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \qquad \Delta H^{\ddot{o}} = -588\ kJ$$

According to the data above, what is the enthalpy of formation of carbon monoxide in $kJ\ mol^{-1}$?

A. –87

B. –99

C. –173

D. –220

19. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g) \qquad \Delta H^{\ddot{o}} = -137 \text{ kJ}$

Which statement about the information above is correct?

A. The total energy of the bonds broken in the reactants is **greater** than the total energy of the bonds formed in the product

B. The bonds broken and the bonds made are of the same strength

C. The total energy of the bonds broken in the reactants is **less** than the total energy of the bonds formed in the product

D. No conclusion can be made about the sums of the bond enthalpies in the product compared with the reactants.

20. When 50 cm^3 of 1 $mol\,dm^{-3}$ HCl is mixed with 50 cm^3 of 1 $mol\,dm^{-3}$ NaOH, the temperature of the resulting solution increases by 6 °C. What will be the temperature change when 100 cm^3 of each of these solutions are mixed?

A. 3 °C

B. 6 °C

C. 12 °C

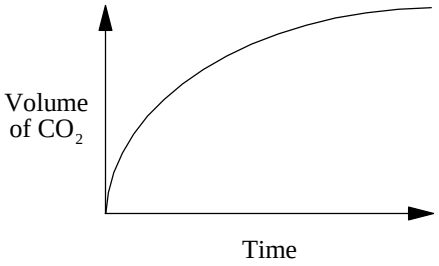
D. 24 °C

21. $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

What are the signs of ΔH and ΔS for this reaction?

	ΔH	ΔS
A.	+	+
B.	–	–
C.	+	–
D.	–	+

22.



The curve above is obtained for the reaction of an excess of $CaCO_3$ with hydrochloric acid. How and why does the rate of reaction change with time?

	Rate of reaction	Reason
A.	decreases	the HCl becomes more dilute
B.	decreases	the pieces of $CaCO_3$ become smaller
C.	increases	the temperature increases
D.	increases	the CO_2 produced acts as a catalyst

23. The rate equation for the reaction between O_2 and NO is

$$\text{Rate} = k[O_2][NO]^2$$

By what factor would the rate of this reaction increase if the concentrations of O_2 and NO are both doubled?

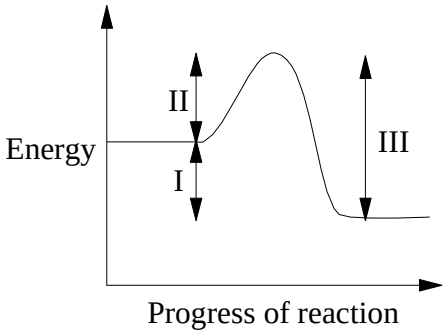
A. $\frac{1}{8}$

B. 3

C. 4

D. 8

24.



Which energy value(s) will change when a catalyst is added?

A. I only

B. II only

C. II and III only

D. I, II and III

25. $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$

Methanol is made in industry by means of the reaction above. The equilibrium expression for this reaction is

A. $\dfrac{[CH_3OH]}{2[H_2][CO]}$

B. $\dfrac{[CH_3OH]}{[H_2]^2[CO]}$

C. $\dfrac{2[H_2][CO]}{[CH_3OH]}$

D. $\dfrac{[H_2]^2[CO]}{[CH_3OH]}$

26. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -91.8 \text{ kJ}$

The industrial synthesis of ammonia is based on the reaction above. Which factor(s) will increase the equilibrium concentration of ammonia?

I. Increase in pressure

II. Increase in temperature

A. I only

B. II only

C. Both I and II

D. Neither I nor II

27. Which is the correct combination?

	Intermolecular forces	**Boiling point**	ΔH_{vap}
A.	weak	low	low
B.	weak	low	high
C.	strong	high	low
D.	strong	low	low

28. When the pH of a solution changes from 2.0 to 4.0, the hydrogen ion concentration

A. increases by a factor of 100.

B. increases by a factor of 2.

C. decreases by a factor of 2.

D. decreases by a factor of 100.

29. Which will be the same for separate 1 mol dm^{-3} solutions of a strong acid and a weak acid?

I. Electrical conductivity

II. Concentration of H^+ ions

A. I only

B. II only

C. Both I and II

D. Neither I nor II

30. What is the K_a of a 0.10 mol dm^{-3} solution of a weak monoprotic acid if the $[H^+] = 2.0 \times 10^{-3}$ mol dm^{-3}?

A. 2.0×10^{-2} mol dm^{-3}

B. 2.0×10^{-4} mol dm^{-3}

C. 4.0×10^{-5} mol dm^{-3}

D. 4.0×10^{-7} mol dm^{-3}

31. A buffer solution will be formed by combining equal volumes of 0.1 mol dm^{-3} solutions of

A. hydrochloric acid and sodium hydroxide.

B. hydrochloric acid and sodium ethanoate.

C. ethanoic acid and sodium hydroxide.

D. ethanoic acid and sodium ethanoate.

32. Which is **not** a redox reaction?

A. $3H_2 + N_2 \rightarrow 2NH_3$

B. $N_2O_4 \rightarrow 2NO_2$

C. $Cl_2 + 2NaI \rightarrow 2NaCl + I_2$

D. $2H_2O_2 \rightarrow 2H_2O + O_2$

33. The same quantity of electricity was passed through separate molten samples of aluminium oxide and sodium chloride. How many moles of sodium will be produced if 0.2 moles of oxygen gas were formed?

A. 0.1

B. 0.2

C. 0.4

D. 0.8

34.

$$2AgNO_3(aq) + Zn(s) \rightarrow 2Ag(s) + Zn(NO_3)_2(aq)$$

$$Zn(NO_3)_2(aq) + Co(s) \rightarrow \text{No reaction}$$

$$2AgNO_3(aq) + Co(s) \rightarrow Co(NO_3)_2(aq) + 2Ag(s)$$

Using the above information, the order of **increasing** activity of the metals is

A. $Ag < Zn < Co$

B. $Co < Ag < Zn$

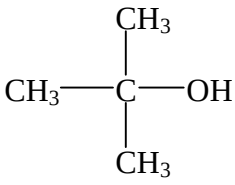
C. $Co < Zn < Ag$

D. $Ag < Co < Zn$

35. Which compound gives **two** distinct peaks in its NMR spectrum?

A. C_6H_6

B. C_2H_5OH

C. 

D. CH_3OCH_3

36. Which substance is most likely to react with hydroxide ions by means of a S_N1 mechanism?

A. C_6H_5Cl

B. $(CH_3)_3CCl$

C. $(CH_3)_2CHCH_2Cl$

D. $CH_3CH_2CH_2CH_2Cl$

37. When the compounds below are listed in order of **decreasing** boiling point (highest to lowest) what is the correct order?

1. ethane 2. fluoroethane 3. ethanol 4. ethanoic acid

A. 4, 3, 1, 2

B. 4, 3, 2, 1

C. 3, 4, 1, 2

D. 2, 1, 3, 4

38. Which reagent reacts with $CH_3CH_2COCH_3$?

I. $LiAlH_4$

II. $H^+ / K_2Cr_2O_7$

A. I only

B. II only

C. Both I and II

D. Neither I nor II

39. Which compound can show optical activity?

A. CH_3COOH

B. H_2NCH_2COOH

C. $HOCH(CH_3)COOH$

D. $(CH_3)_3CCOOH$

40. How many different structural isomers have the formula C_4H_9Cl?

A. 2

B. 3

C. 4

D. 5