INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 16 May 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

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. According to the equation:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

what volume of air (20 % O_2) is required to react with 10 dm^3 of SO_2?

A. 2 dm^3

B. 5 dm^3

C. 10 dm^3

D. 25 dm^3

2. Which of the following compounds has the greatest **empirical** formula mass?

A. C_6H_6

B. C_4H_{10}

C. C_3H_6

D. C_2H_6

3.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

When heated, $CaCO_3$ ($M_r = 100$) decomposes as shown above. When 20 g of impure $CaCO_3$ is heated, 0.15 moles of CO_2 are obtained. What is the percentage purity of the $CaCO_3$? (Assume that none of the impurities produce CO_2 upon heating.)

A. 15

B. 25

C. 55

D. 75

4. $$vC_2H_3Cl(g) + wO_2(g) \rightarrow xCO_2(g) + yH_2O(g) + zHCl(g)$$

Chloroethene can be burned in oxygen as shown above. What is the value of w when $v = 2$?

A. 2

B. 3

C. 4

D. 5

5. Which of the following particles contain more electrons than **neutrons**?

I. ${}^{1}_{1}H$

II. ${}^{35}_{17}Cl^{-}$

III. ${}^{39}_{19}K^{+}$

A. I only

B. II only

C. I and II only

D. II and III only

6. The first four ionisation energies ($kJ\,mol^{-1}$) for a particular element are 550, 1064, 4210 and 5500 respectively. This element should be placed in the same Group as

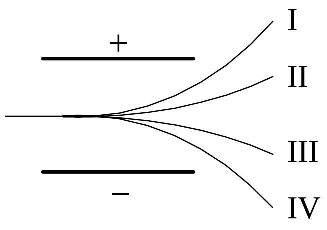
A. Li

B. Be

C. B

D. C

7. A certain element with two isotopes of masses M and $M+2$ is introduced into a mass spectrometer, vaporised and ionised. Which of the following paths are most likely for the resulting ions?



	M	$M+2$
A.	I	IV
B.	II	I
C.	IV	III
D.	IV	II

8. A certain element has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$. Which oxidation state(s) would this element most likely show?

A. +2 only

B. +3 only

C. +2 and +5 only

D. +2, +3, +4, +5

9. Which one of the following increases in value from Li to Cs?

A. Atomic radius

B. Electronegativity

C. Ionisation energy

D. Melting point

10. Which of the following chlorides give neutral solutions when added to water?

I. NaCl

II. Al_2Cl_6

III. PCl_3

A. I only

B. I and II only

C. II and III only

D. I, II and III

11. In which of the following is there at least one double bond?

I. O_2

II. CO_2

III. C_2H_4

A. I only

B. III only

C. II and III only

D. I, II and III

12. According to VSEPR theory, which molecule would be expected to have the **smallest** bond angle?

A. H_2O

B. H_2CO

C. CH_4

D. NH_3

13. Which of the following can exist in **both** polar and non-polar forms?

A. CH_2Cl_2

B. C_2HCl

C. $C_2H_2Cl_2$

D. C_2H_3Cl

14. What are the states of hybridisation for the carbon atoms in $NCCH_2COOH$?

	CN	CH_2	COOH
A.	sp	sp^3	sp^2
B.	sp	sp^2	sp^3
C.	sp^2	sp^2	sp^3
D.	sp^2	sp^3	sp^2

15. Which of the following best accounts for the observation that gases are easily compressed?

A. Gas molecules have negligible attractive forces for one another.

B. The volume occupied by the gas is much greater than that occupied by the molecules.

C. The average energy of the molecules in a gas is proportional to the absolute temperature of the gas.

D. The collisions between gas molecules are elastic.

16. Which expression represents the density of a gas sample of relative molar mass, M_r, at temperature, T, and pressure, P?

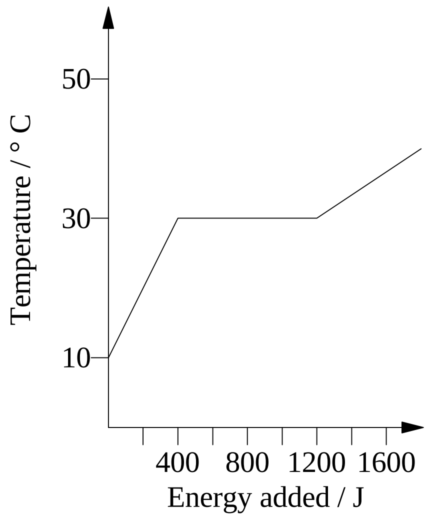
A. $\frac{PM_r}{T}$

B. $\frac{RT}{PM_r}$

C. $\frac{PM_r}{RT}$

D. $\frac{RM_r}{PT}$

17.



The heating curve for 10 g of a substance is given above. How much energy would be required to melt completely 20 g of the substance that is initially at 10° C?

A. 2400 J

B. 1200 J

C. 800 J

D. 400 J

18.

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \qquad \Delta H = 180.4 \text{ kJ}$$
$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g) \qquad \Delta H = 66.4 \text{ kJ}$$

Use the enthalpy values above to calculate ΔH for the reaction;

$$NO(g) + \tfrac{1}{2}O_2(g) \rightarrow NO_2(g)$$

A. −57 kJ

B. −114 kJ

C. 57 kJ

D. 114 kJ

19. In which reaction is the change in entropy (ΔS) closest to zero?

A. $SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$

B. $Br_2(l) \rightarrow Br_2(g)$

C. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

D. $3Ca(s) + N_2(g) \rightarrow Ca_3N_2(s)$

20. The Born–Haber cycle for the formation of potassium chloride includes the steps below:

I. $K(g) \rightarrow K^+(g) + e^-$

II. $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$

III. $Cl(g) + e^- \rightarrow Cl^-(g)$

IV. $K^+(g) + Cl^-(g) \rightarrow KCl(s)$

Which of these steps are exothermic?

A. I and II only

B. III and IV only

C. I, II and III only

D. I, III and IV only

21. Some collisions between reactant molecules do not form products. This is most likely because

A. the molecules do not collide in the proper ratio.

B. the molecules do not have enough energy.

C. the concentration is too low.

D. the reaction is at equilibrium.

22. Doubling which one of the following will double the rate of a first order reaction?

A. Concentration of the reactant

B. Size of solid particles

C. Volume of solution in which the reaction is carried out

D. Activation energy

23. $$F_2(g) + 2ClO_2(g) \rightarrow 2FClO_2(g)$$

The following data were obtained for the reaction above. Use these data to determine the orders for the reactants F_2 and ClO_2.

$[F_2(g)]$ / mol dm^{-3}	$[ClO_2(g)]$ / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
0.1	0.01	1.2×10^{-3}
0.1	0.04	4.8×10^{-3}
0.2	0.01	2.4×10^{-3}

	Order of reaction F_2	ClO_2
A.	1	1
B.	1	2
C.	2	1
D.	2	4

24. $$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197.8 \text{ kJ}$$

The reaction above is an important step in the production of sulfuric acid. An increase in which of the following will increase the ratio of $\frac{SO_3(g)}{SO_2(g)}$ at equilibrium?

A. Pressure only

B. Temperature only

C. Both temperature and pressure

D. Neither pressure nor temperature

25. $$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

The equilibrium constant for the reaction above is 1.0×10^{-14} at 25° C and 2.1×10^{-14} at 35° C. What can be concluded from this information?

A. $[H_3O^+]$ decreases as the temperature is raised.

B. $[H_3O^+]$ is greater than $[OH^-]$ at 35° C.

C. Water is a stronger electrolyte at 25° C.

D. The ionisation of water is endothermic.

26. $$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

What is the equilibrium expression for the reaction above?

A. $K_c = \dfrac{[NH_3]}{[N_2][H_2]}$

B. $K_c = \dfrac{2[NH_3]}{[N_2][H_2]}$

C. $K_c = \dfrac{2[NH_3]}{3[N_2][H_2]}$

D. $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$

27. 10 cm^3 of an HCl solution with a pH value of 2 was mixed with 90 cm^3 of water. What will be the pH of the resulting solution?

A. 1

B. 3

C. 5

D. 7

28. $$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$$

In the equilibrium above, what are the two conjugate bases?

A. CH_3COOH and H_2O

B. CH_3COO^- and H_3O^+

C. CH_3COOH and H_3O^+

D. CH_3COO^- and H_2O

29. Which of the following is the weakest acid in aqueous solution?

A. C_6H_5OH $K_a = 1.3 \times 10^{-10}$

B. HCN $K_a = 4.9 \times 10^{-10}$

C. H_2Se $K_a = 1.5 \times 10^{-4}$

D. HF $K_a = 6.9 \times 10^{-4}$

30. Which salt will produce the most alkaline solution when dissolved in water?

A. KNO_3

B. $MgCl_2$

C. CH_3CO_2Na

D. $(NH_4)_2SO_4$

31. In the electrolysis of molten sodium chloride, the sodium ion goes to the

A. positive electrode where it undergoes oxidation.

B. negative electrode where it undergoes oxidation.

C. positive electrode where it undergoes reduction.

D. negative electrode where it undergoes reduction.

32. Which one of the following could reduce $Cr_2O_7^{2-}(aq)$ to $Cr^{3+}(aq)$?

A. $Ca^{2+}(aq)$

B. $Cu^{2+}(aq)$

C. $Fe^{2+}(aq)$

D. $Zn^{2+}(aq)$

33.

$$\begin{array}{ll} Tl^{+}(aq) + e^{-} \rightarrow Tl(s) & E^{ö} = -0.336\ V \\ Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s) & E^{ö} = 0.339\ V \end{array}$$

The standard electrode potentials for two metals are given above. What are the equation and cell potential for the spontaneous reaction that occurs?

A. $Tl^{+}(aq) + Cu^{2+}(aq) \rightarrow Tl(s) + Cu(s)$ $\quad E^{ö} = 0.003\ V$

B. $2Tl(s) + Cu^{2+}(aq) \rightarrow 2Tl^{+}(aq) + Cu(s)$ $\quad E^{ö} = 0.675\ V$

C. $2Tl(s) + Cu^{2+}(aq) \rightarrow 2Tl^{+}(aq) + Cu(s)$ $\quad E^{ö} = 1.011\ V$

D. $2Tl^{+}(aq) + Cu(s) \rightarrow 2Tl(s) + Cu^{2+}(aq)$ $\quad E^{ö} = 0.333\ V$

34. When molten magnesium chloride is electrolysed, how many moles of gaseous chlorine will be produced for every mole of magnesium?

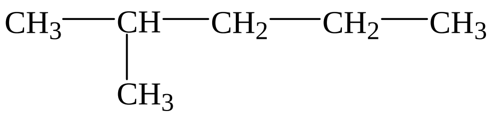
A. $\frac{1}{2}$

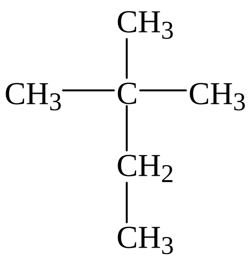
B. 1

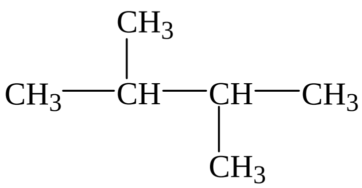
C. 2

D. 4

35. Which names are correct for the following isomers of C_6H_{14}?

I.  2-methylpentane

II.  2-ethyl-2-methylpropane

III.  2,3-dimethylbutane

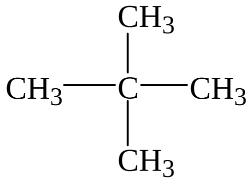
A. I only

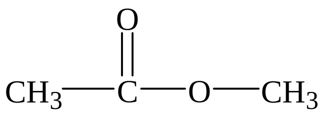
B. I and II only

C. I and III only

D. I, II and III

36. Which of the compounds below will show a single peak in its ^{1}H-NMR spectrum?

I. 

II. 

III. CH_3CH_2OH

A. I only

B. III only

C. I and II only

D. I, II and III

37. What is the correct order of reaction types in the following sequence?

$$C_2H_5Cl \xrightarrow{\mathrm{I}} C_2H_5OH \xrightarrow{\mathrm{II}} CH_3COOH \xrightarrow{\mathrm{III}} CH_3COOCH_3$$

	I	II	III
A.	substitution	oxidation	esterification
B.	addition	substitution	substitution
C.	oxidation	substitution	addition
D.	substitution	oxidation	substitution

38. Which carbon-containing product is most likely from the reaction of C_2H_4 and Br_2?

A. C_2H_5Br

B. $C_2H_4Br_2$

C. C_2H_3Br

D. $C_2H_2Br_2$

39. Which of the following is expected to be a gas at 25° C?

A. $CH_3-\overset{\overset{\displaystyle O}{||}}{C}-CH_3$

B. $CH_3-CH_2-\overset{\overset{\displaystyle O}{||}}{C}-H$

C. $CH_3-O-CH_2-CH_3$

D. $CH_3-\overset{\overset{\displaystyle O}{||}}{C}-OH$

40. Which of the compounds below is/are more likely to undergo substitution, rather than addition, reactions?

I. CH_3CHCH_2

II. $(CH_3)_3CCl$

III. C_6H_6

A. I only

B. II only

C. I and III only

D. II and III only