INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 13 November 2001 (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. $PbS(s) + O_2(g) \rightarrow PbO(s) + SO_2(g)$

The reaction of lead(II) sulfide with oxygen at high temperatures is represented by the unbalanced equation above. What is the sum of the coefficients in the **balanced** equation?

A. 4

B. 5

C. 8

D. 9

2. 8.0 g of a pure compound contains 3.2 g of sulfur and 4.8 g of oxygen. What is its empirical formula?

A. SO

B. SO_2

C. SO_3

D. S_2O_3

3. $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Powdered zinc reacts with Cu^{2+} ions according to the equation above. What will be the result of adding 3.25 g of Zn to 100 cm^3 of 0.25 $mol\,dm^{-3}$ $CuSO_4$ solution?

A. All the Cu^{2+} ions react and some solid zinc remains.

B. All the Cu^{2+} ions react and no solid zinc remains.

C. All the solid zinc reacts and Cu^{2+} ions remain.

D. Neither solid zinc nor Cu^{2+} ions remain.

4. Consider the composition of particles **W**, **X**, **Y**, **Z** below. Which two particles are isotopes of the same element?

Particle	Number of protons	Number of neutrons	Number of electrons
W	11	12	10
X	12	12	12
Y	12	13	12
Z	13	14	10

A. W and X

B. X and Y

C. Y and Z

D. W and Z

5. In which of the following ground-state electron configurations are unpaired electrons present?

I. $1s^2 2s^2 2p^2$

II. $1s^2 2s^2 2p^3$

III. $1s^2 2s^2 2p^4$

A. II only

B. I and II only

C. II and III only

D. I, II and III

6. Which atom or ion has the electron configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 ?$$

A. Co

B. Mn

C. Co^{2+}

D. Fe^{3+}

7. When the species Br, Br^+ and Br^- are arranged in order of increasing size (smallest first), what is the correct order?

A. $Br < Br^+ < Br^-$

B. $Br < Br^- < Br^+$

C. $Br^+ < Br < Br^-$

D. $Br^- < Br < Br^+$

8. When sodium oxide and sulfur dioxide are added to separate test tubes containing water, the solutions will be, respectively,

A. acidic and acidic.

B. acidic and basic.

C. basic and basic.

D. basic and acidic.

9. $$Fe(H_2O)_6^{3+}(aq) + 6CN^-(aq) \rightarrow Fe(CN)_6^{3-}(aq) + 6H_2O(l)$$

In the equation above the cyanide ions act as

A. Brønsted bases.

B. Lewis acids.

C. ligands.

D. reducing agents.

10. The geometry and bond angle of the sulfite ion (SO_3^{2-}) are best described as

A. pyramidal, 107°.

B. tetrahedral, 109°.

C. bent, 104°.

D. trigonal planar, 120°.

11. As the size of the halogen molecules, X_2, increases down the group, their boiling points

A. decrease due to decreasing electronegativity.

B. decrease due to decreasing bond energies.

C. increase due to increasing permanent dipole–dipole attraction.

D. increase due to increasing van der Waals' forces.

12. The length of the bond between carbon and oxygen is shortest in

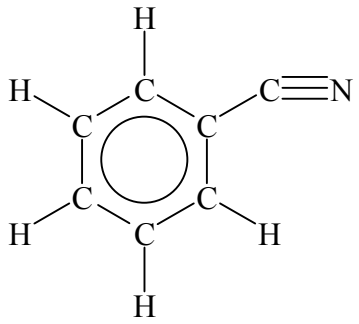
A. CO.

B. CO_2.

C. CH_3CH_2OH.

D. CH_3CHO.

13. What type(s) of hybridisation is/are used by carbon in the following compound?



A. sp^2 only

B. sp and sp^2

C. sp and sp^3

D. sp^2 and sp^3

14. In which species can the bonding **not** be described in terms of the delocalisation of π electrons?

A. $CH_3CH_2O^-$

B. $CH_3CO_2^-$

C. O_3

D. NO_3^-

15. When the pressure is increased at constant temperature, the particles in a gas will

A. become smaller.

B. become larger.

C. move faster.

D. be closer together.

16. Which quantity will **not** change for a sample of gas in a sealed rigid container when it is cooled from 100 °C to 75 °C at constant volume?

A. The average energy of the molecules

B. The average speed of the molecules

C. The pressure of the gas

D. The density of the gas

17. When solid ammonium nitrate, $NH_4NO_3(s)$, dissolves in water, the temperature decreases. Which statement about the dissolving of ammonium nitrate in water is correct?

A. It is endothermic with ΔH greater than zero.

B. It is endothermic with ΔH less than zero.

C. It is exothermic with ΔH less than zero.

D. It is exothermic with ΔH greater than zero.

18.

$$O_2(g) \rightarrow 2O(g) \qquad \Delta H = 498 \text{ kJ}$$
$$3O_2(g) \rightarrow 2O_3(g) \qquad \Delta H = 284 \text{ kJ}$$

Using the information above, what is ΔH for the following equation in kJ?

$$O_3(g) \rightarrow 3O(g)$$

A. 214

B. 356

C. 463

D. 605

19. Which change leads to a decrease in entropy for the system?

A. Solid ammonium chloride sublimes.

B. Sodium corrodes in air.

C. Potassium nitrate dissolves in water.

D. Two inert gases mix at constant temperature and pressure.

20. A certain reaction is spontaneous at low temperatures but becomes non-spontaneous as the temperature is raised. Based on this information, what are the signs of ΔH and ΔS?

	ΔH	ΔS
A.	+	+
B.	+	−
C.	−	+
D.	−	−

21. $$Sn(s) + 2Fe^{3+}(aq) \rightarrow Sn^{2+}(aq) + 2Fe^{2+}(aq)$$

Tin metal reacts with aqueous Fe^{3+} ions according to the equation above. Which of the following factors will increase the rate of this reaction?

I. Increasing the Fe^{3+} ion concentration

II. Decreasing the size of the tin pieces

A. I only

B. II only

C. Both I and II

D. Neither I nor II

22. Use the information below to deduce the rate equation for the hypothetical reaction;

$$X + Y \rightarrow Z$$

[X] / mol dm^{-3}	**[Y] / mol dm^{-3}**	**Relative rate**
0.01	0.01	1
0.02	0.01	4
0.02	0.02	4

A. $\text{Rate} = k[X][Y]$

B. $\text{Rate} = k[X]^2$

C. $\text{Rate} = k[Y]^2$

D. $\text{Rate} = k[X]^2[Y]^2$

23. The reaction between NO_2 and CO to give NO and CO_2 is thought to occur by the following mechanism:

$$NO_2 + NO_2 \rightarrow NO + NO_3 \quad \text{slow}$$
$$NO_3 + CO \rightarrow NO_2 + CO_2 \quad \text{fast}$$

What is the rate equation?

A. $\text{Rate} = k[NO_2][CO]$

B. $\text{Rate} = k[NO_3][CO]$

C. $\text{Rate} = k[NO_2]^2[CO]$

D. $\text{Rate} = k[NO_2]^2$

24. Which statement(s) is(are) correct about the effect of adding a catalyst to a system at equilibrium?

I. The rate of the forward reaction increases.

II. The rate of the reverse reaction increases.

III. The yield of the products increases.

A. I only

B. III only

C. I and II only

D. I, II and III

25. $N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad K_c = 5.0 \times 10^{-3}$

In an equilibrium mixture of these two gases, $[N_2O_4] = 5.0 \times 10^{-1}$ mol dm^{-3}. What is the equilibrium concentration of NO_2 in mol dm^{-3}?

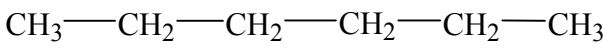
A. 5.0×10^{-1}

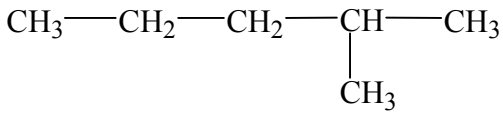
B. 5.0×10^{-2}

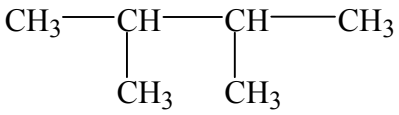
C. 5.0×10^{-3}

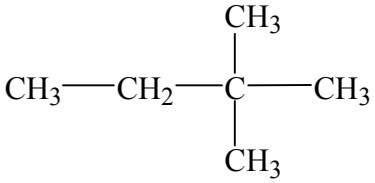
D. 2.5×10^{-4}

26. Which of the isomers of hexane has the highest boiling point?

A. 

B. 

C. 

D. 

27. A Brønsted-Lowry base is defined as a substance which

A. accepts H^+ ions.

B. produces OH^- ions.

C. conducts electricity.

D. donates protons.

28. A 0.1 mol dm^{-3} solution of a weak acid has a $\text{pH} = 3.0$. What is K_a for this acid?

A. 1×10^{-1}

B. 1×10^{-3}

C. 1×10^{-5}

D. 1×10^{-6}

29. The acid HA has an acid dissociation constant, K_a, in aqueous solution. What is the equilibrium constant for the reaction below?

$$A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH^-(aq)$$

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

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

C. K_a

D. $\frac{1}{K_a}$

30. Which statement best describes the difference between solutions of strong and weak acids of equal concentration?

A. Weak acid solutions have lower pH values than strong acids.

B. Weak acid solutions react more slowly with sodium carbonate than strong acids.

C. Weak acid solutions require fewer moles of base for neutralisation than strong acids.

D. Weak acid solutions do not react with magnesium while strong acids do.

31. What is the oxidation number of phosphorus in NaH_2PO_4?

A. +3

B. –3

C. +5

D. –5

32. Which of the following is **not** an oxidation–reduction reaction?

A. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

B. $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

C. $3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow MnO_2(s) + 2MnO_4^-(aq) + 2H_2O(l)$

D. $2CrO_4^{2-}(aq) + 2H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$

33. Use the standard electrode potentials below to determine which of the following statements is correct.

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

A. $Fe^{2+}(aq)$ can spontaneously reduce $Sn^{4+}(aq)$.

B. $Sn^{2+}(aq)$ is a better reducing agent than $Fe^{2+}(aq)$.

C. These two half-reactions can be combined to produce a cell with $E^{\ominus} = 0.92$ V.

D. The $Fe^{3+}(aq)/Fe^{2+}(aq)$ $E^{\ominus}$ value must be multiplied by two when calculating the cell voltage for a reaction between Fe^{3+} and Sn^{2+}.

34. Two moles of electrons are passed through an electrolytic cell containing molten sodium chloride. The same charge is passed through a second cell containing aqueous sodium chloride. In both cells the electrodes are made of platinum. Which statement is correct?

A. One mole of sodium metal will be formed in the first cell.

B. Chlorine gas will be formed at the cathodes of both cells.

C. One mole of hydrogen gas will be formed in the second cell.

D. One mole of oxygen gas will be formed at the anode of the second cell.

35. Which of the following is an amine?

A. $CH_3CH_2NH_2$

B. CH_3CONH_2

C. $-[CH_2CONHCH_2CO]_n-$

D. $CH_3CH_2C \equiv N$

36. $$CH_3OH + CH_3CH_2COOH \overset{H^+}{\rightleftharpoons} CH_3CH_2COOCH_3 + H_2O$$

The forward reaction represented by the equation above is

A. addition.

B. esterification.

C. hydrolysis.

D. oxidation.

37. Which will be the main product when ethanol reacts with excess concentrated phosphoric acid?

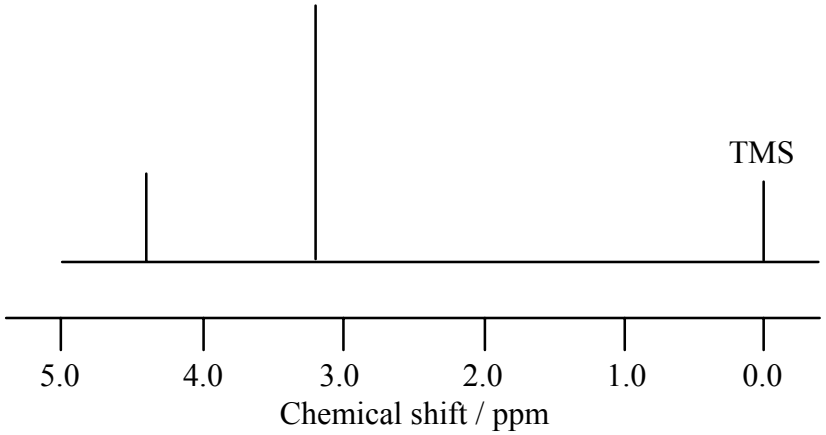
A. Ethene

B. Methoxymethane

C. Ethanoic acid

D. Ethanal

38.



The low resolution ^{1}H-NMR spectrum shown above could be given by

A. CH_3OH .

B. CH_3CH_2OH .

C. HCHO.

D. HCOOH.

39. Which substance dissolves in water to give a neutral solution?

A. CH_3COOH

B. CH_3COONa

C. $CH_3CH_2NH_2$

D. CH_3CONH_2

40. Which one of the following **cannot** be obtained by oxidising 2-methylpropan-1-ol under suitable conditions?

A. An alkanal

B. An alkanone

C. An alkanoic acid

D. Carbon dioxide and water