INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M99/420/H(1)

CHEMISTRY

Higher Level

Thursday 6 May 1999 (afternoon)

Paper 1 — 1 hour

This examination paper consists of 40 questions.

Each question offers 4 suggested answers.

The maximum mark for this paper is 40.

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.

Calculators are NOT permitted for this examination paper.

EXAMINATION MATERIALS

Required:
Optically Mark Read (OMR) answer sheet

Allowed:
A simple translating dictionary for candidates not working in their own language

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 sample has the greatest mass?

A. 1.0 mol of N_2H_4

B. 2.0 mol of N_2

C. 3.0 mol of NH_3

D. 25.0 mol of H_2

2. A compound contains 24 % magnesium, 28 % silicon and 48 % oxygen by mass. What is its empirical formula?

A. MgSiO

B. Mg_2SiO

C. $MgSi_2O$

D. $MgSiO_3$

3. What is the mass in grams of one **molecule** of propanol, C_3H_7OH ?
(Avogadro's constant 6.0×10^{23} mol^{-1})

A. 60

B. 1.0×10^{-22}

C. 1.0×10^{-23}

D. 3.6×10^{25}

4. Chloroethene, C_2H_3Cl, reacts with oxygen according to the equation below:

$$2C_2H_3Cl + 5O_2 \rightarrow 4CO_2 + 2H_2O + 2HCl$$

How many moles of CO_2 are produced when 3.0 mol of C_2H_3Cl and 3.0 mol of O_2 are reacted?

A. 2.4

B. 3.0

C. 4.0

D. 6.0

5. All isotopes of tin have the same

I. number of protons;

II. number of neutrons;

III. mass number.

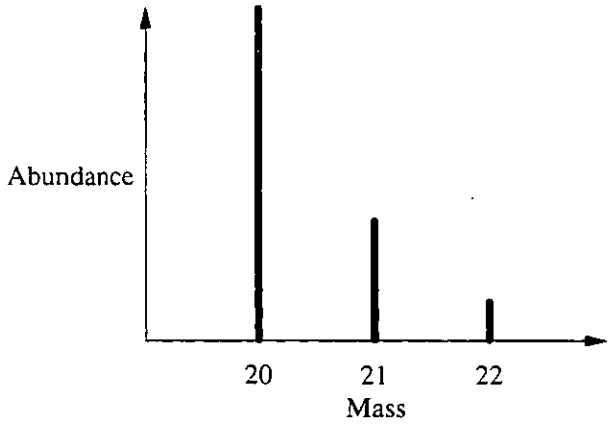
A. I only

B. II only

C. III only

D. I and III only

The following diagram should be used to answer question 6.



6. According to the mass spectrum above, the relative atomic mass of the element shown is best expressed as

A. 20.0.

B. between 20.0 and 21.0.

C. 21.0.

D. between 21.0 and 22.0.

7. Using the Aufbau Principle, deduce which element below has the greatest number of unpaired electrons in its ground state.

A. $Z = 13$

B. $Z = 14$

C. $Z = 15$

D. $Z = 16$

8. Which element has the lowest first ionization energy?

A. Li

B. Na

C. Mg

D. Al

9. Based on melting points, the dividing line between ionic and covalent chlorides of the elements Mg to S lies between

A. Mg and Al.

B. Al and Si.

C. Si and P.

D. P and S.

10. In which region of the Periodic Table would the element with the electronic structure below be located?

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^6 5s^2$$

A. group 6

B. noble gases

C. s block

D. d block

11. Which compound contains both covalent and ionic bonds?

A. sodium carbonate, Na_2CO_3

B. magnesium bromide, $MgBr_2$

C. dichloromethane, CH_2Cl_2

D. ethanoic acid, CH_3COOH

12. In which of the following gaseous molecules are the bond angles equal to 120° ?

I. BF_3

II. NCl_3

III. SO_3

A. I only

B. I and III only

C. II and III only

D. I, II and III

13. What are the types of hybridization of the carbon atoms in the compound

$$\underset{1}{H_2ClC}—\underset{2}{CH_2}—\underset{3}{COOH}\ ?$$

	1	*2*	*3*
A.	sp^2	sp^2	sp^2
B.	sp^3	sp^2	sp
C.	sp^3	sp^3	sp^2
D.	sp^3	sp^3	sp

14. In which of the following pairs does the second substance have the lower boiling point?

A. F_2 , Cl_2

B. H_2O, H_2S

C. C_2H_6 , C_3H_8

D. CH_3OCH_3 , CH_3CH_2OH

15. All of the following are characteristic properties of gases EXCEPT

A. they can expand without limit.

B. they diffuse readily.

C. they are easily compressed.

D. they have high densities.

16. A 250 cm^3 sample of an unknown gas has a mass of 1.42 g at 35°C and 0.85 atmospheres. Which expression gives its molar mass, M_r? ($R = 82.05\ cm^3\ atm\ K^{-1}\ mol^{-1}$)

A. $\dfrac{1.42 \times 82.05 \times 35}{0.25 \times 0.85}$

B. $\dfrac{1.42 \times 82.05 \times 308}{0.25 \times 0.85}$

C. $\dfrac{1.42 \times 250 \times 0.85}{82.05 \times 308}$

D. $\dfrac{1.42 \times 82.05 \times 308}{250 \times 0.85}$

17. A mixture of 0.40 mol of N_2, 0.20 mol of O_2 and 0.20 mol of CO_2 has a total pressure of 1.6 atmospheres. What is the partial pressure of O_2 in atmospheres?

A. 0.20

B. 0.25

C. 0.32

D. 0.40

18. Excess thionyl chloride, $SOCl_2$, can be removed from a reaction mixture by reacting it with water according to the equation;

$$SOCl_2(l) + H_2O(l) \rightarrow 2HCl(g) + SO_2(g)$$

Use the following data to calculate $\Delta H^{\ominus}$ for this reaction.

	$SOCl_2(l)$	$H_2O(l)$	$HCl(g)$	$SO_2(g)$
$\Delta H_f^{\ominus}$ (kJ mol^{-1})	−245.6	−285.8	−92.3	−296.8

A. −142.3

B. −50.0

C. +50.0

D. +142.3

19. 200 J of energy were given to a 10 g sample of copper. If the temperature of the copper increased by 50°C, what is the specific heat capacity of the copper?

A. 0.25 J g^{-1} °C^{-1}

B. 0.40 J g^{-1} °C^{-1}

C. 2.5 J g^{-1} °C^{-1}

D. 4.0 J g^{-1} °C^{-1}

20. Which of the changes below occurs with the greatest increase in entropy?

A. $Na_2O(s) + H_2O(l) \rightarrow 2Na^+(aq) + 2OH^-(aq)$

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

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

D. $C(s) + CO_2(g) \rightarrow 2CO(g)$

21. For the reaction;

$$3HC{\equiv}CH(g) \rightarrow C_6H_6(g)$$

$\Delta H^{\ominus} = -597.3$ kJ and $\Delta S^{\ominus} = -0.33$ kJ K^{-1}. This reaction

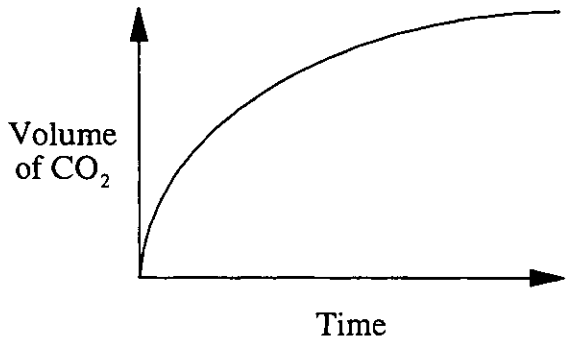
A. is spontaneous at 300K and becomes non-spontaneous at higher temperatures.

B. is spontaneous at 300K and becomes non-spontaneous at lower temperatures.

C. is non-spontaneous at 300K and becomes spontaneous at higher temperatures.

D. is non-spontaneous at 300K and becomes spontaneous at lower temperatures.

22. The reaction between excess calcium carbonate and hydrochloric acid can be followed by measuring the volume of carbon dioxide produced with time. The results of one such reaction are shown below.



How does the rate of this reaction change with time and what is the main reason for this change?

A. The rate increases with time because the calcium carbonate particles get smaller.

B. The rate increases with time because the acid becomes more dilute.

C. The rate decreases with time because the calcium carbonate particles get smaller.

D. The rate decreases with time because the acid becomes more dilute.

23. Most reactions occur in a series of steps, one of which is the rate determining step. The rate determining step is so called because it is the

A. first step.

B. last step.

C. fastest step.

D. slowest step.

24. The reaction between nitrogen dioxide and carbon monoxide is given by the equation below;

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

According to the following experimental data, what is the rate equation?

$[NO_2]$ / mol dm^{-3}	$[CO]$ / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
0.10	0.10	1.0×10^{-6}
0.30	0.10	9.0×10^{-6}
0.30	0.30	9.0×10^{-6}

A. Rate $= k[NO_2][CO]$

B. Rate $= k[CO]^2$

C. Rate $= k[NO_2]^2$

D. Rate $= k[NO_2]^3$

25. For a reaction which goes to completion, the equilibrium constant, K_c, is

A. $>> 1$

B. $<< 1$

C. $= 1$

D. $= 0$

26. The reaction between sulfur dioxide and oxygen occurs according to the equation below;

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H^{\ominus} = -197 \text{ kJ}$$

A higher equilibrium concentration of SO_3 will be produced by all of the following changes in reaction conditions EXCEPT

A. increasing the pressure.

B. adding more O_2.

C. adding a catalyst.

D. decreasing the temperature.

27. The reaction between methane and hydrogen sulfide is represented by the equation below;

$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$

What is the equilibrium expression for this reaction?

A. $[CS_2][H_2]/[CH_4][H_2S]$

B. $4[CS_2][H_2]/2[CH_4][H_2S]$

C. $[CS_2]+4[H_2]/[CH_4]+2[H_2S]$

D. $[CS_2][H_2]^4/[CH_4][H_2S]^2$

28. Which of the following 1 mol dm^{-3} solutions will be the poorest conductor of electricity?

A. hydrochloric acid

B. ethanoic acid

C. sodium hydroxide

D. ammonium chloride

29. In the equilibrium below;

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

which species represent a conjugate acid–base pair?

A. CH_3COOH / H_2O

B. CH_3COO^- / H_3O^+

C. H_2O / CH_3COO^-

D. H_3O^+ / H_2O

30. Which of the following combinations produce a buffer solution when equal volumes are mixed?

I. 0.1M HCl and 0.1M NH_4Cl

II. 0.1M HCl and 0.2M NH_3

III. 0.1M NH_3 and 0.1M NH_4Cl

A. I only

B. III only

C. II and III only

D. I, II and III

31. In which reaction below does the **first** species listed react as a Lewis acid?

A. $H_2O + HPO_4^{2-} \rightleftharpoons H_2PO_4^- + OH^-$

B. $H^+ + NH_3 \rightleftharpoons NH_4^+$

C. $NO_2^- + H_3O^+ \rightleftharpoons HNO_2 + H_2O$

D. $NH_4^+ + HS^- \rightleftharpoons H_2S + NH_3$

32. Zinc metal can supply electrons to copper ions and magnesium metal can supply electrons to zinc ions. Which is the strongest reducing agent?

A. copper ions

B. zinc ions

C. magnesium metal

D. zinc metal

33. A student constructs a voltaic cell using tin and lead electrodes. What is the e.m.f. for the spontaneous reaction? The electrode potentials are:

$$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s) \qquad E^\ominus = -0.14\ V$$
$$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s) \qquad E^\ominus = -0.13\ V$$

A. 0.27 V

B. 0.01 V

C. –0.01 V

D. –0.27 V

34. For which of the reactions below will $\Delta G^\ominus$ be the most negative?

A. $Cu(s) + 2Ag^+(aq) \rightarrow 2Ag(s) + Cu^{2+}(aq) \qquad E^\ominus = 0.46\ V$

B. $Co(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Co^{2+}(aq) \qquad E^\ominus = 0.62\ V$

C. $H_2(g) + Cd^{2+}(aq) \rightarrow Cd(s) + 2H^+(aq) \qquad E^\ominus = -0.40\ V$

D. $Fe^{2+}(aq) + Cu^{2+}(aq) \rightarrow Fe^{3+}(aq) + Cu^+(aq) \qquad E^\ominus = -0.61\ V$

35. The most appropriate conditions for converting iodomethane to methanol are, warming iodomethane with

A. water.

B. dilute sulfuric acid.

C. dilute aqueous sodium hydroxide.

D. silver nitrate solution.

36. For which of the following transformations does the reactive carbon undergo a change in hybridization?

A. alkane to chloroalkane

B. acid to alkanal

C. acid to ester

D. alkanol to acid

37. A gaseous alkane and a gaseous alkene are treated separately in the following ways. Which treatment will distinguish between them?

A. They are ignited in excess oxygen.

B. They are passed over heated copper.

C. They are bubbled through an aqueous solution of bromine.

D. They are bubbled through an aqueous solution of propanal.

38. Polymers formed from monomers with the general formula $H_2C=CHX$

A. have the same percentage of carbon as the monomer.

B. are produced by substitution reactions.

C. contain C=C bonds.

D. are more reactive than the monomer.

39. How many lines would be expected in the proton NMR spectrum of benzene, C_6H_6?

A. 1

B. 2

C. 6

D. 42

40. Which one of the following compounds is optically active?

A. $CH_3CH_2CH_2CH_2NH_2$

B. $CH_3CH_2\underset{\displaystyle NH_2}{\underset{|}{C}}HCH_3$

C. $CH_3CH_2\underset{\displaystyle H}{\underset{|}{N}}CH_2CH_3$

D. $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{N}}CH_3$