INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

N99/420/H(1)

Key

CHEMISTRY

Higher Level

Tuesday 16 November 1999 (afternoon)

Paper 1	Grade	1	2	3	4	5	6	7	1 hour
	Boundaries	0-10	11-16	17-21	22-25	26-28	29-31	32→	

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 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																	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. What is the empirical formula for a compound with the molecular formula $C_6H_3(NO_2)_3$?

C_2HNO_2

A. CHNO

(B.) C_2HNO_2

C. $(C_2HNO_2)_3$

D. $C_6H_3N_3O_6$

2. Arsenic, As_4, reacts with oxygen to produce the oxide As_4O_{10}. What is the **sum** of the coefficients for the **reactants** in the balanced equation?

$$\underbrace{1\,As_4 + 5\,O_2}_{1+5=6} \rightarrow 1\,As_4O_{10}$$

A. 4

B. 5

(C.) 6

D. 7

3. What is the minimum number of grams of O_2 ($M_R = 32$) required to burn 1.6 grams of CH_4 ($M_R = 16$) according to the equation below?

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

1 mol 2 mol

16 g 64 g

1·6 g 6·4 g

A. 1.6

B. 3.2

(C.) 6.4

D. 32

4. How many moles of HCl are in 25 cm^3 of 0.2 mol dm^{-3} hydrochloric acid?

(A.) 0.005

$n = cV = \frac{25}{1000}\,dm^3 \times 0.2\,\frac{mol}{dm^3} = \frac{5}{1000}\,mol$

$= 0.005\,mol$

B. 0.008

C. 5

D. 8

5. Which species contains 16 protons, 17 neutrons and 18 electrons?

A. $^{32}S^-$ 16p 17e⁻ ×

(B) $^{33}S^{2-}$ 16p, 17n, 18e⁻

C. $^{34}S^-$ 16p 17e⁻ ×

D. $^{35}S^{2-}$ 16p 19n 18e⁻ ×

6. Values for the **first** ionisation energies (IE) for five successive elements in the Periodic Table are given below. Based on these values, which statement is correct?

Element	K	L	M	N	O	P
IE (kJ mol^{-1})	1060	1000	1260	1520	418	?

A. The outermost electron in element K is in a higher energy level that that in element L

B. Element M is probably a metal ×

(C.) Element N is probably a non-metal

D. Element P has a lower first ionisation than element O ×

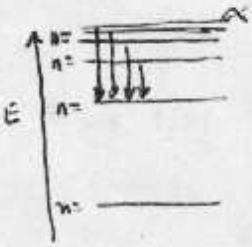
7. Spectra have been used to study the arrangements of electrons in atoms. An emission spectrum consists of a series of bright lines that converge at high frequencies. Such emission spectra provide evidence that electrons are moving from

A. lower to higher energy levels with the higher energy levels being closer together.

B. lower to higher energy levels with the lower energy levels being closer together.

C. higher to lower energy levels with the lower energy levels being closer together.

(D.) higher to lower energy levels with the higher energy levels being closer together.



8. Which property of alkali metals changes as stated with increasing atomic number?

A. Atomic radius decreases ×

B. Reactivity with water decreases ×

C. Electronegativity increases ×

(D) Melting point decreases metals: valence e⁻s further from the nucleus

9. Which reaction occurs readily?

ox. strength $Cl_2 > Br_2 > I_2$

I. $Br_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Br^-(aq)$ ✓ Br_2 can displace I_2 from I^-

II. $Br_2(aq) + 2Cl^-(aq) \rightarrow Cl_2(aq) + 2Br^-(aq)$ ✗ Br_2 can NOT displace Cl_2 from Cl^-

(A.) I only

B. II only

C. Both I and II

D. Neither I nor II

10. Which ion is colourless?

A. $[Cr(H_2O)_6]^{3+}$ ✓

B. $[Fe(CN)_6]^{4-}$ ✓

C. $[Cu(NH_3)_4]^{2+}$ ✓

(D.) $[Zn(H_2O)_4]^{2+}$

11. Which substance exhibits only ionic bonding?

A. $NaNO_3$ ✗ Na^+ NO_3^- ~ 2×non-metal ⇒ covalent bonding

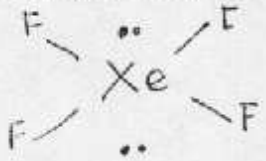
B. H_2SO_4 ✗ SO_4^{2-} "

C. NH_4Cl ✗ NH_4^+ "

(D.) $MgBr_2$ Mg^{2+} $2Br^-$ ~ only ionic bonding

12. Which molecule or ion does **not** have a tetrahedral shape?

(A.) XeF_4 ✓ square planar

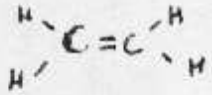


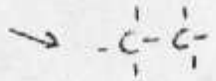
B. $SiCl_4$ ✓

C. BF_4^- ✓

D. NH_4^+ ✓

13. When the substances below are arranged in order of increasing carbon–carbon bond length (shortest bond first), what is the correct order?

I. H_2CCH_2 

II. H_3CCH_3 

III. 

A. I < II < III

B. I < III < II

C. II < I < III

D. III < II < I

14. What type(s) of intermolecular forces is/are present in CH_3OCH_3?

A. dipole–dipole, hydrogen bonds and van der Waals'

B. dipole–dipole and van der Waals' only

C. hydrogen bonds and van der Waals' only

D. van der Waals' only

15. Dry air contains 1 % argon by volume. What is the partial pressure of argon in dry air at one atmosphere pressure (101 kPa)?

A. 1.01 kPa

B. 10.1 kPa

C. 101 kPa

D. 10100 kPa

16. The boiling points of **four** hydrocarbons are given. Which pair will mix most easily at the temperature specified?

	T_b / K
cyclohexane	354
cycloheptane	392
cyclooctane	421
cyclononane	444

A. cyclohexane and cycloheptane at 380 K

B. cycloheptane and cyclooctane at 390 K

(C.) cyclooctane and cyclononane at 460 K

D. cyclononane and cyclohexane at 420 K

temp. at which solid & liquid are at equilibrium with each other.

17. What changes occur when ice at its melting point is converted to liquid water?

I. movement of the molecules increases X ← temp. remains the same.

II. distance between molecules increases ✓

$H_2O_{(s)} \overset{0^\circ C}{\rightleftharpoons} H_2O_{(l)}$

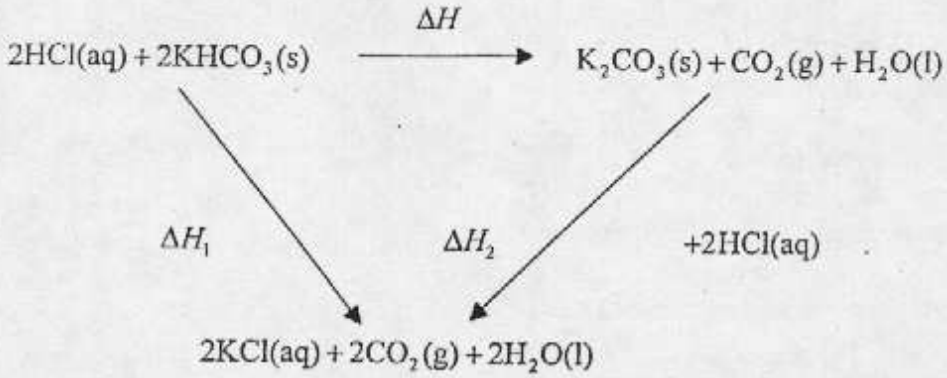
(A.) I only

B. II only

C. Both I and II

D. Neither I nor II

18.



This cycle may be used to determine ΔH for the decomposition of potassium hydrogen carbonate. Which expression can be used to calculate ΔH?

A. $\Delta H = \Delta H_1 + \Delta H_2$

B. $\Delta H = \Delta H_1 - \Delta H_2$

C. $\Delta H = \frac{1}{2}\Delta H_1 - \Delta H_2$

D. $\Delta H = \Delta H_2 - \Delta H_1$

19. A sodium hydroxide solution is reacted with excess hydrochloric acid. What information is **not** needed to calculate the molar heat of neutralisation of sodium hydroxide?

A. Initial temperatures of both solutions

B. Volumes of both solutions

C. Concentration of the hydrochloric acid solution

D. Maximum temperature of the mixture

20. Which factor(s) will cause the lattice enthalpy of ionic compounds to increase in magnitude?

I. an increase in the charge on the ions

II. an increase in the size of ions

A. I only

B. II only

C. Both I and II

D. Neither I nor II

21. How would this reaction at 298 K be described in thermodynamic terms?

heat + $2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$ (decomposition rxn)

(A.) Endothermic with a significant increase in entropy

B. Endothermic with a significant decrease in entropy

C. Exothermic with a significant increase in entropy

D. Exothermic with a significant decrease in entropy

22. The rate of reaction of a strip of magnesium and 50 cm^3 of 1 mol dm^{-3} HCl is measured at 25° C. In which case would **both** new conditions contribute to an increase in the rate of reaction?

A. Mg powder and 100 cm^3 of 1 mol dm^{-3} HCl

B. Mg powder and 50 cm^3 of 0.8 mol dm^{-3} HCl

C. 100 cm^3 of 1 mol dm^{-3} HCl at 30° C

(D.) 50 cm^3 of 1.2 mol dm^{-3} HCl at 30° C

23. The rate constant for a certain reaction has the units **concentration^{-1} time^{-1}**. What is the order of reaction?

A. 0

B. 1

(C.) 2

D. 3

$rate = k_2 [A]^2$

$\frac{conc}{time} = k_2\, conc^2$ $\therefore k_2 = \frac{1}{conc.\,time} = conc^{-1}\, time^{-1}$

24. The addition of a catalyst to a chemical reaction alters the rate primarily by

A. changing the enthalpy of the reaction.

B. increasing the number of collisions between the reactant molecules in a given time.

C. increasing the fraction of reactant molecules with a given kinetic energy.

(D.) providing a different reaction pathway.

} temp effects

25. Chemical equilibrium is referred to as **dynamic** because, at equilibrium, the

A. equilibrium constant changes. ✗

(B.) reactants and products keep reacting. rate of forward rxn = rate of reverse rxn

C. rates of the forward and backward reactions change. ✗

D. concentrations of the reactants and products continue to change. ✗

26. An equimolar mixture of propan-1-ol (bp = 97.4° C) and propan-2-ol (bp = 82.4° C) is boiled in a flask to which a distillation column is attached. What is true about the first sample of vapour that enters the distillation column? → lower V.pr. → higher V.pr

A. It is pure propan-1-ol. ✗

B. It is pure propan-2-ol. ✗

C. It contains a higher fraction of propan-1-ol than propan-2-ol. ✗

(D.) It contains a higher fraction of propan-2-ol than propan-1-ol.

27. Which change(s) will increase the amount of $SO_3(g)$ at equilibrium?

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \quad \Delta H = -200 \text{ kJ}$$ heat

I. Increasing the temperature ✗

II. Decreasing the volume ✓ 3 mol → 2 mol

III. Adding a catalyst ✗

A. I only

(B.) II only

C. I and III only

D. I, II and III

28. $NH_3(aq) + HNO_2(aq) \rightarrow NH_4^+(aq) + NO_2^-(aq)$

For this reaction, a Brønsted-Lowry acid is

A. $NH_3(aq)$ because it contains the largest number of hydrogen atoms.

B. $NH_3(aq)$ because it accepts a proton from $HNO_2(aq)$.

C. $HNO_2(aq)$ because it has lone pairs of electrons on the oxygen atoms.

D. $HNO_2(aq)$ because it donates a proton to $NH_3(aq)$.

29. The K_a values of acids HX, HY and HZ are given. What is the correct order when these acids are arranged in order of increasing strength (weakest first)?

$HX\ K_a = 1\times10^{-4}$ $HY\ K_a = 1\times10^{-5}$ $HZ\ K_a = 3\times10^{-5}$

A. $HX < HY < HZ$

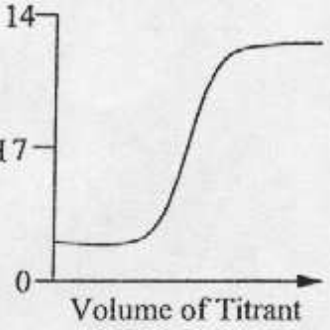
B. $HX < HZ < HY$

C. $HZ < HY < HX$

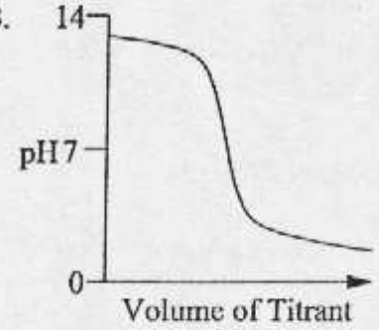
D. $HY < HZ < HX$

30. Which titration curve represents the titration of a weak base with a strong acid?

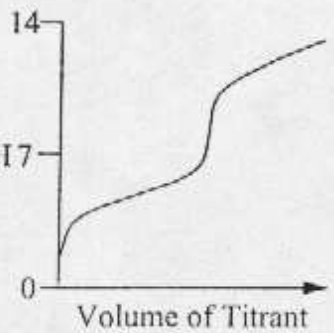
A.



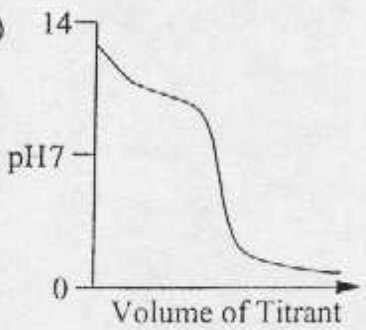
B.



C.



D.



31. What is the pH of a buffer solution that contains 0.1 mol dm^{-3} HA and 0.1 mol dm^{-3} NaA?

(HA $K_a = 1\times10^{-5}$)

A. pH = 3

B. pH = 4

C. pH = 5

D. pH = 6

$HA \rightleftharpoons H^+ + A^-$
0·1 0·1

$K_a = \frac{[H^+][A^-]}{[HA]} = [H^+]$

$\therefore pH = pK_a = 5$

32. For which conversion is an oxidising agent required?

(one which is reduced) → oxidises another substance

A. $\underset{-1}{Cl^-}(aq) \rightarrow \underset{+1}{OCl^-}(aq)$

B. $\underset{+6}{SO_3}(g) \rightarrow \underset{+6}{SO_4^{2-}}(aq)$ Not a redox rxn

C. $\underset{+1}{2H^+}(aq) \rightarrow \underset{0}{H_2}(g)$ reduction

D. $S_4O_6^{2-}(aq) \rightarrow 2S_2O_3^{2-}(aq)$ ✗

$S_4O_6^{2-}$: $4x + 6(-2) = -2$; $4x + 10$; $x = +2\frac{1}{2}$

$S_2O_3^{2-}$: $2x - 6 = -2$; $2x = +4$; $x = +2$

reduction

33. The standard electrode potentials for tin and silver are given. What is the equation for the spontaneous reaction together with its cell potential?

$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ $\quad E^\ominus = -0.14$ V
$Ag^+(aq) + e^- \rightarrow Ag(s)$ $\quad E^\ominus = 0.80$ V

A. $Sn^{2+}(aq) + 2Ag(s) \rightarrow Sn(s) + 2Ag^+(aq)$ $\quad E_{cell} = -1.74$ V

B. $Sn^{2+}(aq) + 2Ag(s) \rightarrow Sn(s) + 2Ag^+(aq)$ $\quad E_{cell} = -0.94$ V

C. $Sn(s) + 2Ag^+(aq) \rightarrow Sn^{2+}(aq) + 2Ag(s)$ $\quad E_{cell} = +0.94$ V

D. $Sn(s) + 2Ag^+(aq) \rightarrow Sn^{2+}(aq) + 2Ag(s)$ $\quad E_{cell} = +1.74$ V

$Sn_{(s)} \rightarrow Sn^{2+}_{(aq)} + 2e^-$ $E^\ominus = +0.14$ V
$2Ag^+_{(aq)} + 2e^- \rightarrow 2Ag_{(s)}$ $E^\ominus = +0.80$
$E^\ominus_{cell} = +0.94$ V

34. What mass of oxygen will be produced when a current of 0.2 A is passed through an aqueous solution of sulphuric acid for 1 hour?

$C = 0.2 \times 60 \times 60$

$2H_2O_{(l)} \rightarrow O_{2\,(g)} + 4e^- + 4H^+$

$4 \times 96500\ C$ per mol of O_2

$\therefore$ amount $n = \frac{0.2 \times 60 \times 60}{4 \times 96500}$ mol

$\therefore$ mass $= \frac{0.2 \times 60 \times 60}{4 \times 96500}$ mol $\times 32$ g/mol

A. $\frac{(96500 \times 32)}{(0.2 \times 60 \times 60)}$

B. $\frac{(0.2 \times 60 \times 60 \times 32)}{(96500)}$

C. $\frac{(0.2 \times 60 \times 60 \times 32)}{(2 \times 96500)}$

(D.) $\frac{(0.2 \times 60 \times 60 \times 32)}{(4 \times 96500)}$ (too many steps involved)

35.

$$CH_3(CH_2)_2\overset{\overset{O}{\|}}{C}O(CH_2)_4CH_3$$

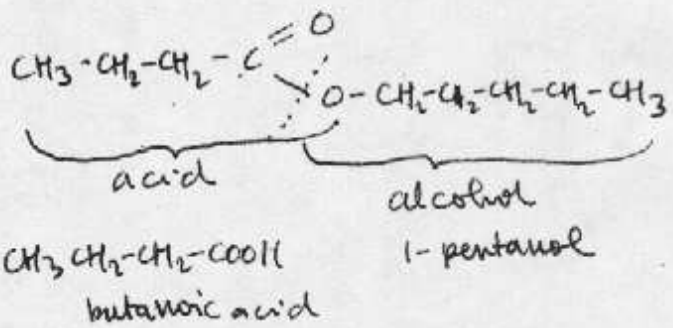
From which **two** chemicals could this compound be synthesised?

(A.) butanoic acid and pentan-1-ol

B. butanoic acid and butan-1-ol

C. butanal and pentan-1-ol

D. pentanoic acid and butan-1-ol



$CH_3CH_2CH_2COOH$ butanoic acid

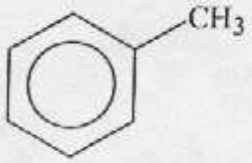
1-pentanol

36. Which chemical is most likely to be a starting material for a common polymer?

A. $CH_3CH_2CH_3$

B. CH_3CH_2OH

(C.) CH_3CHCH_2 $\quad CH_3 - CH = CH_2$

D. 

37. 0.1 mol dm^{-3} aqueous solutions of these organic compounds were prepared. When these solutions are arranged in order of increasing pH (lowest pH first), what is the correct order?

I. $CH_3CH_2CH_2OH$ neutral → must acidic

II. $CH_3CH_2CH_2NH_2$ w. base

III. CH_3CH_2COOH W. Acid

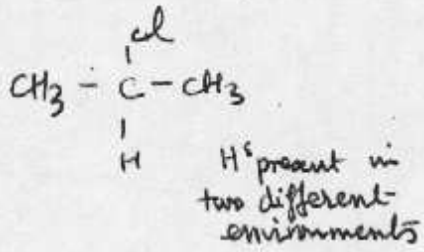
A. I < II < III

B. III < I < II

C. II < III < I

D. III < II < I

38. How many different hydrogen signals would be present in the ^1H NMR spectrum of 2-chloropropane, $CH_3CHClCH_3$?



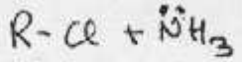
A. One

B. Two

C. Three

D. Seven

39. What is the major product when an halogenoalkane (alkyl halide) is reacted with a large excess of ammonia?



A. An amine

B. An amide

C. A tetraalkyl ammonium halide

D. An alkene

40. What type of reaction does benzene, C_6H_6, typically undergo?

A. Addition

B. Elimination

C. Reduction

D. Substitution