IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 20 May 2002 (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. A compound that contains only carbon, hydrogen and oxygen has the following percentage by mass:

carbon 60 %, hydrogen 8 %, oxygen 32 %.

What is a possible molecular formula?

A. $C_5H_8O_2$

B. C_5H_4O

C. C_6HO_3

D. C_7HO_4

2. Which sample contains the smallest amount of oxygen?

A. 0.3 mol H_2SO_4

B. 0.6 mol O_3

C. 0.7 mol HCOOH

D. 0.8 mol H_2O

3. 6.4 g of copper wire is added to 0.10 dm^3 of 1.0 $mol\,dm^{-3}$ aqueous $AgNO_3$ to form metallic silver and aqueous copper(II) nitrate. When the reaction is complete,

A. excess copper wire remains.

B. all the copper wire dissolves and some silver ions are left in solution.

C. all the copper wire dissolves and no silver ions are left in solution.

D. the mass of metallic silver formed is equal to the mass of copper wire that reacts.

4. 2.02 g of KNO_3 ($M_r = 101$) is dissolved in sufficient water to prepare 0.500 dm^3 of solution. What is the concentration of this solution in $mol\,dm^{-3}$?

A. 0.02

B. 0.04

C. 0.10

D. 0.20

5. Copper consists of the isotopes ^{63}Cu and ^{65}Cu and has a relative atomic mass of 63.55. What is the most likely composition?

	^{63}Cu	**^{65}Cu**
A.	30 %	70 %
B.	50 %	50 %
C.	55 %	45 %
D.	70 %	30 %

6. Which of the following atoms has/have one or more unpaired electrons?

I. Iron
II. Copper
III. Zinc

A. I only
B. III only
C. I and II only
D. I, II and III

7. Atomic line spectra provide information about the …**I**… in atoms through the …**II**….

	I	**II**
A.	energy levels	distance between lines
B.	atomic mass	pattern of the lines
C.	number of electrons	number of lines
D.	nuclear charge	intensity of the lines

8. In which pair is the first species larger than the second?

A. Cl and Cl^-

B. Na^+ and Na

C. Na and K

D. Si and Cl

9. The oxides of the elements of the third period (Na → Cl) become more …**I**… and produce more …**II**… solutions when added to water.

	I	**II**
A.	ionic	acidic
B.	ionic	alkaline
C.	covalent	acidic
D.	covalent	alkaline

10. Which of the following reactions is/are spontaneous?

I. $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$

II. $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$

A. I only

B. II only

C. Both I and II

D. Neither I nor II

11. When the Lewis structure for $HCOOCH_3$ is drawn, how many bond pairs and how many lone pairs of electrons are present?

	Bond pairs	**Lone pairs**
A.	8	4
B.	7	5
C.	7	4
D.	5	5

12. The carbon–carbon–carbon bond angle in CH_3CHCH_2 is closest to

A. 180°.

B. 120°.

C. 109°.

D. 90°.

13. The delocalisation of electrons is most likely to be significant in

A. CO_2.

B. SO_2.

C. HCOOH.

D. TiO_2.

14. The shape of the triiodide ion, I_3^-, is best described as

A. bent.

B. linear.

C. T-shaped.

D. triangular.

15. What occurs during the change from a liquid to a solid at a fixed temperature?

A. The particles become smaller and heat is released.

B. The particles get closer together and heat is absorbed.

C. The particles become more ordered and heat is released.

D. The attractive forces between the particles become stronger and heat is absorbed.

16. The molar mass of an unknown gas is to be determined by weighing a sample. As well as its mass, which of the following must be known?

I. Pressure

II. Temperature

III. Volume

A. I only

B. II only

C. I and II only

D. I, II and III

17. A mixture of 0.6 mol N_2, 0.4 mol O_2 and 0.2 mol H_2 has a total pressure of 2.0 atmospheres. What is the partial pressure of N_2 in atmospheres?

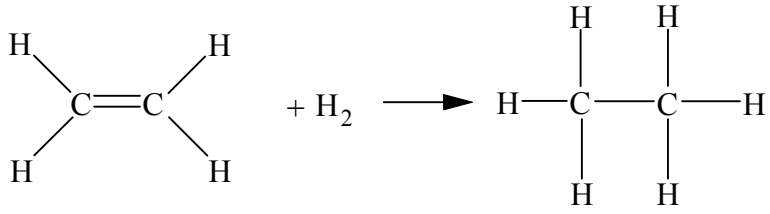
A. 0.5

B. 0.6

C. 1.0

D. 1.2

18. What is the value of ΔH (in kJ mol^{-1}) for the reaction below?



Bond Energies / kJ mol^{-1}	H—H	C—C	C = C	C—H
	436	348	612	412

A. 124

B. 101

C. –101

D. –124

19. Using the information below:

$$H_2(g) + O_2(g) \rightarrow H_2O_2(l) \qquad \Delta H = -187.6 \text{ kJ}$$
$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \qquad \Delta H = -571.6 \text{ kJ}$$

what is the value of ΔH (in kJ) for the following reaction?

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

A. –196.4

B. –384.0

C. –759.2

D. –946.8

20. For which of the following is the change in entropy, ΔS, closest to zero?

A. $H_2O(l) \rightarrow H_2O(g)$

B. $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$

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

D. $Mg(s) + H_2O(l) \rightarrow MgO(s) + H_2(g)$

21. When $\Delta G^{\ominus}$ for a reaction is negative, the reaction is

A. fast.

B. endothermic.

C. reversible.

D. spontaneous.

22. $$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which change will increase the rate of the above reaction when 50 cm^3 of 1.0 $mol\,dm^{-3}$ HCl is added to 1.0 g of $CaCO_3$?

A. The volume of HCl is increased.

B. The concentration of HCl is decreased.

C. The size of the $CaCO_3$ solid particles is decreased.

D. The pressure of the CO_2 is increased.

23. Which statement(s) about the following reaction at 100 °C is/are correct?

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

I. Every collision between N_2 and H_2 molecules is expected to produce NH_3.

II. This reaction must involve a collision between one N_2 and three H_2 molecules.

A. I only

B. II only

C. Both I and II

D. Neither I nor II

24. The rate of a chemical reaction increases with increasing temperature. This increase in reaction rate is due to

I. an increase in the collision rate.

II. a decrease in the activation energy.

III. an increase in the number of molecules that react.

A. I only

B. II only

C. I and III only

D. I, II and III

25. For a gaseous reaction, the equilibrium constant expression is:

$$K_c = \frac{[O_2]^5[NH_3]^4}{[NO]^4[H_2O]^6}.$$

Which equation corresponds to this equilibrium expression?

A. $4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$

B. $4NO + 6H_2O \rightleftharpoons 4NH_3 + 5O_2$

C. $8NH_3 + 10O_2 \rightleftharpoons 8NO + 12H_2O$

D. $2NO + 3H_2O \rightleftharpoons 2NH_3 + \frac{5}{2}O_2$

26. The reaction

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

is exothermic. Which of the following could be used to shift the equilibrium to the right?

I. Increasing the pressure

II. Increasing the temperature

A. I only

B. II only

C. Both I and II

D. Neither I nor II

27. Which combination is correct?

	$\Delta H_{\text{vaporisation}}$	**Boiling point**	**Intermolecular forces**
A.	large	high	strong
B.	large	low	weak
C.	small	low	strong
D.	small	high	weak

28. Solutions **P**, **Q**, **R** and **S** have the following properties:

P: $pH = 8$ **Q**: $[H^+] = 1 \times 10^{-3}$ mol dm^{-3} **R**: $pH = 5$ **S**: $[H^+] = 2 \times 10^{-7}$ mol dm^{-3}

When these solutions are arranged in order of increasing acidity (least acidic first), the correct order is

A. **P**, **S**, **R**, **Q**.

B. **Q**, **R**, **S**, **P**.

C. **S**, **R**, **P**, **Q**.

D. **R**, **P**, **Q**, **S**.

29. The ionisation of sulfuric acid is represented by the equations below:

$$H_2SO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$$
$$HSO_4^-(aq) + H_2O(l) \rightarrow H_3O^+(aq) + SO_4^{2-}(aq)$$

What is the conjugate base of $HSO_4^-(aq)$?

A. $H_2O(l)$

B. $H_3O^+(aq)$

C. $H_2SO_4(aq)$

D. $SO_4^{2-}(aq)$

30. What are the $[H^+]$ and $[OH^-]$ in a 0.10 $mol\,dm^{-3}$ solution of a weak acid ($K_a = 1.0\times10^{-7}$)?

	$[H^+]$	**$[OH^-]$**
A.	1.0×10^{-1}	1.0×10^{-13}
B.	1.0×10^{-3}	1.0×10^{-11}
C.	1.0×10^{-4}	1.0×10^{-10}
D.	1.0×10^{-6}	1.0×10^{-8}

31. Which of the following combinations will form a buffer solution?

I. 20 cm^3 0.10 $mol\,dm^{-3}$ CH_3COOH and 10 cm^3 0.10 $mol\,dm^{-3}$ CH_3COONa

II. 20 cm^3 0.10 $mol\,dm^{-3}$ CH_3COOH and 10 cm^3 0.10 $mol\,dm^{-3}$ NaOH

A. I only

B. II only

C. Both I and II

D. Neither I nor II

32. Which of the following changes represents a reduction reaction?

A. $Mn^{2+}(aq) \rightarrow MnO_4^-(aq)$

B. $CrO_4^{2-}(aq) \rightarrow Cr^{3+}(aq)$

C. $2CrO_4^{2-}(aq) \rightarrow Cr_2O_7^{2-}(aq)$

D. $MnO_2(s) \rightarrow MnO_4^{2-}(aq)$

33. The standard electrode potentials for Al and Mn are given below:

$$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s) \qquad -1.66 \text{ V}$$
$$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s) \qquad -1.18 \text{ V}$$

What is the potential of a cell prepared with these metals in contact with 1.0 $mol\,dm^{-3}$ solutions of their ions?

A. 0.22 V

B. 0.48 V

C. 2.84 V

D. 3.43 V

34. When an aqueous solution of copper(II) chloride is electrolysed using carbon electrodes, the products are

	negative electrode	**positive electrode**
A.	hydrogen gas	chlorine gas
B.	hydrogen gas	oxygen gas
C.	copper metal	oxygen gas
D.	copper metal	chlorine gas

35. The following compounds have similar molar masses. Which compound has the highest boiling point?

A. CH_3COOH

B. $C_2H_5OCH_3$

C. CH_3COCH_3

D. C_2H_5Cl

36. Which molecule possesses a chiral centre?

A. NH_2CH_2COOH

B. $CH_3CH(NH_2)COOH$

C. $CH_3C(NH_2)_2COOH$

D. $(CH_3)_2C(NH_2)COOH$

37. Which reaction occurs at room temperature?

A. $CH_3CH_2CH_2NH_2 + OH^- \rightarrow CH_3CH_2CH_2OH + NH_2^-$

B. $CH_3CH_2CH_2OCH_3 + CN^- \rightarrow CH_3CH_2CH_2OCN + CH_3^-$

C. $CH_3CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2OH + Br^-$

D. $(CH_3)_3COH + Cl^- \rightarrow (CH_3)_3CCl + OH^-$

38. Which compound will undergo oxidation when treated with acidified potassium dichromate(VI)?

A. CH_3CH_2CHO

B. CH_3COCH_3

C. CH_3COOH

D. $(CH_3)_3COH$

39. Which compound reacts by electrophilic substitution?

A. 1-Bromobutane

B. Cyclohexane

C. Methylbenzene

D. Propanone

40. The mass spectrum of $CH_3COOC_2H_5$ is **not** expected to show a major ion peak at which m/e ratio?

A. 88

B. 32

C. 29

D. 15