

**CHEMISTRY  
HIGHER LEVEL  
PAPER 1**

Wednesday 14 May 2003 (afternoon)

1 hour

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**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.

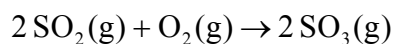
The Periodic Table

		Atomic Number										2					
		Element															
		Atomic Mass															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 <b>H</b> 1.01												5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01											13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31											31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.71	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.37	49 <b>In</b> 114.82	50 <b>Sn</b> 118.69	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.30
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> 98.91	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.40	81 <b>Tl</b> 204.37	82 <b>Pb</b> 207.19	83 <b>Bi</b> 208.98	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.34	57 † <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.21	76 <b>Os</b> 190.21	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.09	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 ‡ <b>Ac</b> (227)			
			58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> 146.92	62 <b>Sm</b> 150.35	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.92	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97	
			90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)	

1. What amount of oxygen,  $O_2$ , (in moles) contains  $1.8 \times 10^{22}$  molecules?

- A. 0.0030
- B. 0.030
- C. 0.30
- D. 3.0

2.  $3.0 \text{ dm}^3$  of sulfur dioxide are reacted with  $2.0 \text{ dm}^3$  of oxygen according to the equation:



What volume of sulfur trioxide (in  $\text{dm}^3$ ) is formed? (Assume the reaction goes to completion and all gases are measured at the same temperature and pressure.)

- A. 5.0
- B. 4.0
- C. 3.0
- D. 2.0

3. What volume (in  $\text{dm}^3$ ) of  $0.30 \text{ mol dm}^{-3}$  NaCl solution can be prepared from 0.060 mol of solute?

- A. 0.018
- B. 0.20
- C. 0.50
- D. 5.0

4. Consider the composition of the species W, X, Y and Z below. Which species is an anion?

Species	Number of protons	Number of neutrons	Number of electrons
W	9	10	10
X	11	12	11
Y	12	12	12
Z	13	14	10

- A. W
- B. X
- C. Y
- D. Z
5. What is the electron configuration for an atom with  $Z = 22$ ?
- A.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$
- B.  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^2$
- C.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4p^2$
- D.  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
6. Which is related to the number of electrons in the outer main energy level of the elements from the alkali metals to the halogens?
- I. Group number
- II. Period number
- A. I only
- B. II only
- C. Both I and II
- D. Neither I nor II

7. Which of the following salts form coloured solutions when dissolved in water?



A. I and II only

B. II and III only

C. III and IV only

D. I, II, III and IV

8. The compounds  $\text{Na}_2\text{O}$ ,  $\text{Al}_2\text{O}_3$  and  $\text{SO}_2$  respectively are

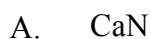
A. acidic, amphoteric and basic.

B. amphoteric, basic and acidic.

C. basic, acidic and amphoteric.

D. basic, amphoteric and acidic.

9. What is the formula for the compound formed by calcium and nitrogen?



10. What is the best description of the carbon-oxygen bond lengths in  $\text{CO}_3^{2-}$  ?

A. One short and two long bonds

B. One long and two short bonds

C. Three bonds of the same length

D. Three bonds of different lengths

11. Which of the following is true for  $\text{CO}_2$ ?

	<b>C=O bond</b>	<b><math>\text{CO}_2</math> molecule</b>
A.	polar	non-polar
B.	non-polar	polar
C.	polar	polar
D.	non-polar	non-polar

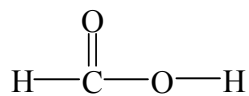
12. The molar masses of  $\text{C}_2\text{H}_6$ ,  $\text{CH}_3\text{OH}$  and  $\text{CH}_3\text{F}$  are very similar. How do their boiling points compare?

- A.  $\text{C}_2\text{H}_6 < \text{CH}_3\text{OH} < \text{CH}_3\text{F}$
- B.  $\text{CH}_3\text{F} < \text{CH}_3\text{OH} < \text{C}_2\text{H}_6$
- C.  $\text{CH}_3\text{OH} < \text{CH}_3\text{F} < \text{C}_2\text{H}_6$
- D.  $\text{C}_2\text{H}_6 < \text{CH}_3\text{F} < \text{CH}_3\text{OH}$

13. What is the distribution of electron pairs and the arrangement of atoms in the triiodide ion,  $\text{I}_3^-$ ?

	<b>Electron pairs</b>	<b>Atom arrangement</b>
A.	tetrahedral	bent
B.	square planar	linear
C.	trigonal bipyramid	linear
D.	trigonal bipyramid	bent

14. What is the number of sigma ( $\sigma$ ) and pi ( $\pi$ ) bonds and the hybridization of the carbon atom in



	<b>Sigma</b>	<b>Pi</b>	<b>Hybridization</b>
A.	4	1	$sp^2$
B.	4	1	$sp^3$
C.	3	2	$sp^3$
D.	3	1	$sp^2$

15. Solid, liquid and gaseous water are all present at very low pressure near  $0^\circ\text{C}$ . How do the distances between the molecules in the three states compare under these conditions?

- A. The distances are equal in all three states.
- B. Distances are similar in the solid and liquid, which are smaller than that in the gas.
- C. Distances are smallest in the solid, and similar in the liquid and gas.
- D. Distances are smallest in the liquid, and similar in the solid and the gas.

16. In which gas sample do molecules have the greatest average kinetic energy?

- A.  $\text{H}_2$  at 100 K
- B.  $\text{CH}_4$  at 273 K
- C.  $\text{H}_2\text{O}$  at 373 K
- D.  $\text{CH}_3\text{OH}$  at 353 K

17. What energy changes occur when chemical bonds are formed and broken?
- A. Energy is absorbed when bonds are formed and when they are broken.
- B. Energy is released when bonds are formed and when they are broken.
- C. Energy is absorbed when bonds are formed and released when they are broken.
- D. Energy is released when bonds are formed and absorbed when they are broken.

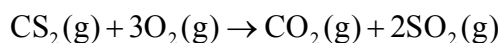
18. Which combination of ionic charge and ionic radius give the largest lattice enthalpy for an ionic compound?

	<b>Ionic charge</b>	<b>Ionic radius</b>
A.	high	large
B.	high	small
C.	low	small
D.	low	large

19. Under what conditions is a reaction spontaneous at all temperatures?

	$\Delta H^\ominus$	$\Delta S^\ominus$
A.	+	+
B.	+	-
C.	-	-
D.	-	+

20. What is  $\Delta H$  for the reaction below in kJ?



$[\Delta H_f / \text{kJ mol}^{-1} : \text{CS}_2(\text{g}) 110, \text{CO}_2(\text{g}) - 390, \text{SO}_2(\text{g}) - 290]$

- A. -570
- B. -790
- C. -860
- D. -1080



21. Which of the following is (are) important in determining whether a reaction occurs?

- I. Energy of the molecules
- II. Orientation of the molecules

- A. I only
- B. II only
- C. Both I and II
- D. Neither I nor II

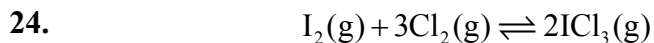
22. The reaction between  $\text{NO}_2$  and  $\text{F}_2$  gives the following rate data at a certain temperature. What is the order of reaction with respect to  $\text{NO}_2$  and  $\text{F}_2$ ?

$[\text{NO}_2]/\text{mol dm}^{-3}$	$[\text{F}_2]/\text{mol dm}^{-3}$	Rate / $\text{mol dm}^{-3} \text{ min}^{-1}$
0.1	0.2	0.1
0.2	0.2	0.4
0.1	0.4	0.2

	<b><math>\text{NO}_2</math> order</b>	<b><math>\text{F}_2</math> order</b>
A.	first	first
B.	first	second
C.	second	first
D.	second	second

23. Which step in a multi-step reaction is the rate determining step?

- A. The first step
- B. The last step
- C. The step with the lowest activation energy
- D. The step with the highest activation energy



What is the equilibrium constant expression for the reaction above?

A. 
$$K_c = \frac{[\text{ICl}_3]}{[\text{I}_2][\text{Cl}_2]}$$

B. 
$$K_c = \frac{2[\text{ICl}_3]}{3[\text{I}_2][\text{Cl}_2]}$$

C. 
$$K_c = \frac{2[\text{ICl}_3]}{[\text{I}_2] + 3[\text{Cl}_2]}$$

D. 
$$K_c = \frac{[\text{ICl}_3]^2}{[\text{I}_2][\text{Cl}_2]^3}$$

25. Which of the factors below affect the equilibrium vapour pressure of a liquid in a container?

- I. Temperature
- II. Surface of the liquid
- III. Volume of the container

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

26. How does the  $[\text{H}^+]$  in an aqueous solution with  $\text{pH} = 4$  compare with the  $[\text{H}^+]$  in a solution with  $\text{pH} = 2$ ?  
The  $[\text{H}^+]$  is

- A. twice as great.
- B. half as much.
- C.  $\frac{1}{10}$  of the value.
- D.  $\frac{1}{100}$  of the value.

27. Which is a buffer solution?

- I.  $0.01 \text{ mol dm}^{-3} \text{ HCl}, 0.01 \text{ mol dm}^{-3} \text{ NaCl}$
- II.  $0.01 \text{ mol dm}^{-3} \text{ CH}_3\text{COOH}, 0.01 \text{ mol dm}^{-3} \text{ CH}_3\text{COONa}$

- A. I only
- B. II only
- C. Both I and II
- D. Neither I nor II

28. Which **one** of the following species can act as both a Brønsted-Lowry acid and base in aqueous solution?

- A.  $\text{CH}_3\text{COOH}$
- B.  $\text{NO}_3^-$
- C.  $\text{H}_2\text{PO}_4^-$
- D.  $\text{OH}^-$

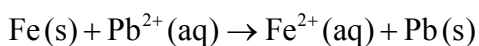
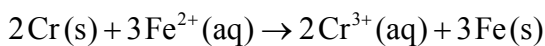
29. The  $K_a$  value for an acid is  $1.0 \times 10^{-2}$ . What is the  $K_b$  value for its conjugate base?

- A.  $1.0 \times 10^{-2}$
- B.  $1.0 \times 10^{-6}$
- C.  $1.0 \times 10^{-10}$
- D.  $1.0 \times 10^{-12}$

30. Separate 20.0 cm<sup>3</sup> solutions of a weak acid and a strong acid of the same concentration are titrated with NaOH solution. Which will be the same for these two titrations?

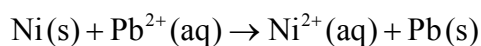
- I. Initial pH
- II. pH at equivalence point
- III. Volume of NaOH required to reach the equivalence point

- A. I only
  - B. III only
  - C. I and II only
  - D. II and III only
31. Which is the strongest reducing agent according to the spontaneous reactions below?

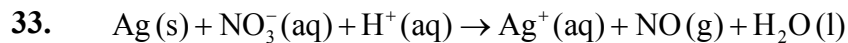


- A. Cr(s)
- B. Cr<sup>3+</sup>(aq)
- C. Pb<sup>2+</sup>(aq)
- D. Pb(s)

32. What occurs during the operation of a voltaic cell based on the reaction:



	External circuit	Ion movement in solution
A.	electrons move from Ni to Pb	Pb <sup>2+</sup> (aq) move away from Pb(s)
B.	electrons move from Ni to Pb	Pb <sup>2+</sup> (aq) move toward Pb(s)
C.	electrons move from Pb to Ni	Ni <sup>2+</sup> (aq) move away from Ni(s)
D.	electrons move from Pb to Ni	Ni <sup>2+</sup> (aq) move toward Ni(s)

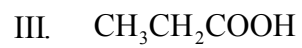
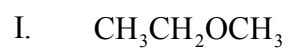


When the oxidation-reduction equation above is balanced, what is the coefficient for  $\text{H}^+(\text{aq})$ ?

- A. 1
- B. 2
- C. 3
- D. 4
34. Aqueous solutions of  $\text{AgNO}_3$ ,  $\text{Cu(NO}_3)_2$  and  $\text{Cr(NO}_3)_3$  are electrolyzed using the same quantity of electricity. How do the number of moles of metal formed compare?
- A.  $\text{Ag} = \text{Cu} = \text{Cr}$
- B.  $\text{Ag} > \text{Cu} > \text{Cr}$
- C.  $\text{Ag} < \text{Cu} < \text{Cr}$
- D.  $\text{Cu} > \text{Ag} > \text{Cr}$
35. Which of the substances below is **least** soluble in water?
- A.  $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$
- B.  $\text{CH}_3\overset{\text{O}}{\parallel}\text{CCH}_3$
- C.  $\text{CH}_3\text{CH}_2\overset{\text{O}}{\parallel}\text{COH}$
- D.  $\text{CH}_3\overset{\text{O}}{\parallel}\text{COCH}_3$

36. What product results from the reaction of  $\text{CH}_2=\text{CH}_2$  with  $\text{Br}_2$ ?
- A.  $\text{CHBrCHBr}$
  - B.  $\text{CH}_2\text{CHBr}$
  - C.  $\text{CH}_3\text{CH}_2\text{Br}$
  - D.  $\text{CH}_2\text{BrCH}_2\text{Br}$
37. How many different tripeptides can be prepared from three amino acids?  
(Each amino acid is used only once in a given tripeptide.)
- A. 1
  - B. 3
  - C. 6
  - D. 9
38. The reaction of  $\text{C}_6\text{H}_6$  with  $\text{Br}_2$  in the presence of a halogen carrier is expected to produce
- A.  $\text{C}_6\text{H}_6\text{Br}$
  - B.  $\text{C}_6\text{H}_6\text{Br}_2$
  - C.  $\text{C}_6\text{H}_4\text{Br}_2 + \text{H}_2$
  - D.  $\text{C}_6\text{H}_5\text{Br} + \text{HBr}$
39. Which compound reacts fastest with water?
- A.  $(\text{CH}_3)_3\text{CBr}$
  - B.  $(\text{CH}_3)_3\text{CCl}$
  - C.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
  - D.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$

40. Which of the following compounds exhibits three lines in the  $^1\text{H NMR}$  spectrum?



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