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CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 9 May 2011 (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.
- The periodic table is provided for reference on page 2 of this examination paper.

The Periodic Table

1	2											3	4	5	6	7	0
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)															

†	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. 1.7 g of $NaNO_3$ ($M_r = 85$) is dissolved in water to prepare 0.20 dm^3 of solution. What is the concentration of the resulting solution in mol dm^{-3}?

A. 0.01

B. 0.1

C. 0.2

D. 1.0

2. What mass, in g, of hydrogen is formed when 3 mol of aluminium react with excess hydrochloric acid according to the following equation?

$$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

A. 3.0

B. 4.5

C. 6.0

D. 9.0

3. The relative molecular mass of a gas is 56 and its empirical formula is CH_2. What is the molecular formula of the gas?

A. CH_2

B. C_2H_4

C. C_3H_6

D. C_4H_8

4. What is the sum of all coefficients when the following equation is balanced using the smallest possible whole numbers?

$$\_\_ C_2H_2 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$$

A. 5

B. 7

C. 11

D. 13

5. What is the electron configuration of vanadium?

A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^3$

B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^1$

D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

6. Which quantities are the same for all atoms of chlorine?

I. Number of protons

II. Number of neutrons

III. Number of electrons

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. Which property generally **decreases** across period 3?

A. Atomic number

B. Electronegativity

C. Atomic radius

D. First ionization energy

8. Which statement about the elements in group 7 is correct?

A. Br_2 will oxidize Cl^-.

B. F_2 has the least tendency to be reduced.

C. Cl_2 will oxidize I^-.

D. I_2 is a stronger oxidizing agent than F_2.

9. Which electron transitions are responsible for the colours of transition metal compounds?

A. Between d orbitals and s orbitals

B. Among the attached ligands

C. From the metal ion to the attached ligands

D. Between d orbitals

10. How many σ and π bonds are present in a molecule of propyne, CH_3CCH?

	σ	π
A.	5	3
B.	6	2
C.	7	1
D.	8	0

11. Which species does **not** contain delocalized electrons?

A. $CH_3CH_2O^-$

B. $CH_3CO_2^-$

C. O_3

D. NO_3^-

12. Which compound forms hydrogen bonds in the liquid state?

A. C_2H_5OH

B. $CHCl_3$

C. CH_3CHO

D. $(CH_3CH_2)_3N$

13. Which particles are responsible for electrical conductivity in metals?

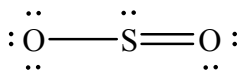
A. Anions

B. Cations

C. Electrons

D. Protons

14. The Lewis structure of SO_2 is given below.



What is the shape of the SO_2 molecule?

A. Bent (V-shaped)

B. Linear

C. T-shaped

D. Triangular planar

15. When hydrogen peroxide decomposes, the temperature of the reaction mixture increases.

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

What are the signs of ΔH, ΔS and ΔG for this reaction?

	ΔH	ΔS	ΔG
A.	–	–	–
B.	–	+	–
C.	+	+	–
D.	–	+	+

16. Which reaction has the greatest increase in entropy?

A. $SO_2(g) + 2H_2S(g) \rightarrow 2H_2O(l) + 3S(s)$

B. $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

C. $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$

D. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

17. Consider the two reactions involving iron and oxygen.

$$2Fe(s) + O_2(g) \rightarrow 2FeO(s) \qquad \Delta H^{\ominus} = -544 \text{ kJ}$$
$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \qquad \Delta H^{\ominus} = -1648 \text{ kJ}$$

What is the enthalpy change, in kJ, for the reaction below?

$$4FeO(s) + O_2(g) \rightarrow 2Fe_2O_3(s)$$

A. –1648 – 2(–544)

B. –544 – (–1648)

C. –1648 – 544

D. –1648 – 2(544)

18. Which statement about bonding is correct?

A. Bond breaking is endothermic and requires energy.

B. Bond breaking is endothermic and releases energy.

C. Bond making is exothermic and requires energy.

D. Bond making is endothermic and releases energy.

19. Which equation corresponds to the lattice enthalpy for silver iodide, AgI?

A. $AgI(s) \rightarrow Ag(s) + I(g)$

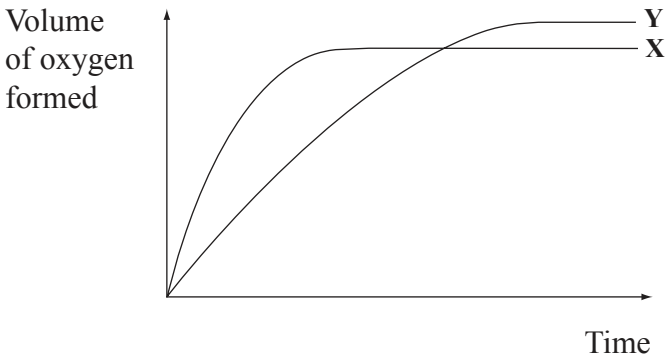
B. $AgI(s) \rightarrow Ag(s) + \frac{1}{2}I_2(g)$

C. $AgI(s) \rightarrow Ag^+(aq) + I^-(aq)$

D. $AgI(s) \rightarrow Ag^+(g) + I^-(g)$

20. Curve **X** on the graph below shows the volume of oxygen formed during the catalytic decomposition of a 1.0 mol dm^{-3} solution of hydrogen peroxide.

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



Which change would produce the curve **Y**?

A. Adding water

B. Adding some 0.1 mol dm^{-3} hydrogen peroxide solution

C. Using a different catalyst

D. Lowering the temperature

21. Bromine and nitrogen(II) oxide react according to the following equation.

$$Br_2(g) + 2NO(g) \rightarrow 2NOBr(g)$$

Which rate equation is consistent with the experimental data?

$[Br_2]$ / mol dm^{-3}	[NO] / mol dm^{-3}	Rate / mol dm^{-3}s^{-1}
0.10	0.10	1.0×10^{-6}
0.20	0.10	4.0×10^{-6}
0.20	0.40	4.0×10^{-6}

A. rate = $k\,[Br_2]^2\,[NO]$

B. rate = $k\,[Br_2]\,[NO]^2$

C. rate = $k\,[Br_2]^2$

D. rate = $k\,[NO]^2$

22. Consider the reaction between gaseous iodine and gaseous hydrogen.

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H^{\ominus} = -9 \text{ kJ}$$

Why do some collisions between iodine and hydrogen **not** result in the formation of the product?

A. The I_2 and H_2 molecules do not have sufficient energy.

B. The system is in equilibrium.

C. The temperature of the system is too high.

D. The activation energy for this reaction is very low.

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

A. The step with the lowest activation energy

B. The final step

C. The step with the highest activation energy

D. The first step

24. Which statement about chemical equilibria implies they are dynamic?

A. The position of equilibrium constantly changes.

B. The rates of forward and backward reactions change.

C. The reactants and products continue to react.

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

25. Which is the correct relationship between enthalpy of vaporization, intermolecular forces and boiling point?

	Enthalpy of vaporization	**Intermolecular forces**	**Boiling point**
A.	small	weak	high
B.	small	strong	low
C.	large	weak	high
D.	large	strong	high

26. Which salts will produce an acidic solution when dissolved in water?

I. CH_3COOK

II. NH_4NO_3

III. $Al_2(SO_4)_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

27. Consider the equilibrium below.

$$CH_3CH_2COOH\,(aq) + H_2O\,(l) \rightleftharpoons CH_3CH_2COO^-\,(aq) + H_3O^+\,(aq)$$

Which species represent a conjugate acid-base pair?

A. CH_3CH_2COOH and H_2O

B. H_2O and $CH_3CH_2COO^-$

C. H_3O^+ and H_2O

D. $CH_3CH_2COO^-$ and H_3O^+

28. The K_b value for a base is 5.0×10^{-2} mol dm^{-3} at 298 K. What is the K_a value for its conjugate acid at this temperature?

A. 5.0×10^{-2}

B. 2.0×10^{-6}

C. 2.0×10^{-12}

D. 2.0×10^{-13}

29. Which compounds can be mixed together as solutions of equal volume and concentration to form a buffer solution?

A. Nitric acid and potassium hydroxide

B. Nitric acid and potassium nitrate

C. Propanoic acid and potassium hydroxide

D. Propanoic acid and potassium propanoate

30. Consider the following standard electrode potentials.

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^{\ominus} = -0.76 \text{ V}$$

$$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq) \qquad E^{\ominus} = +1.36 \text{ V}$$

$$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s) \qquad E^{\ominus} = -2.37 \text{ V}$$

What will happen when zinc powder is added to an aqueous solution of magnesium chloride?

A. No reaction will take place.

B. Chlorine gas will be produced.

C. Magnesium metal will form.

D. Zinc chloride will form.

31. Which species could be reduced to form NO_2?

A. N_2O

B. NO_3^-

C. HNO_2

D. NO

32. What are the features of a standard hydrogen electrode?

I. A temperature of 298 K

II. A carbon electrode

III. Hydrogen gas at 1.01×10^5 Pa (1 atm) pressure

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

33. Which molecule has a chiral centre?

A. $CH_3CH=CHCHO$

B. $(CH_3)_2C=CHCH_2OH$

C. $CH_3OCH_2CH_3$

D. $CH_3CHOHCH_2CH_3$

34. The compounds $H_2NCH_2CH_2NH_2$ and $HOOCCH_2COOH$ react to form a polymer. What is the structure of the repeating unit of the polymer?

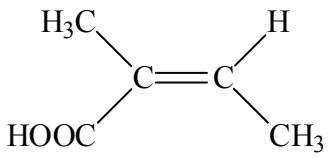
A. $\text{-(}HNCH_2CONHCH_2CH_2NHCO\text{)-}$

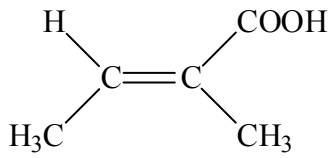
B. $\text{-(}HNCH_2CH_2NHCOCH_2CO\text{)-}$

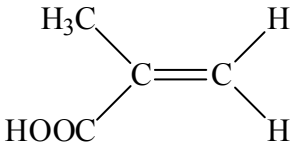
C. $\text{-(}OCCH_2CONHCH_2NHCO\text{)-}$

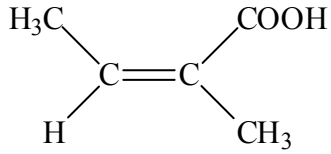
D. $\text{-(}HNCH_2CH_2NHCOCH_2NH\text{)-}$

35. Which two molecules are cis-trans isomers of each other?

W 

X 

Y 

Z 

A. X and Z

B. X and Y

C. W and Y

D. W and Z

36. What is the correct order of reaction types in the following sequence?

$$C_3H_7Br \xrightarrow{\textbf{I}} C_3H_7OH \xrightarrow{\textbf{II}} C_2H_5COOH \xrightarrow{\textbf{III}} C_2H_5COOC_2H_5$$

	I	II	III
A.	substitution	oxidation	condensation
B.	addition	substitution	condensation
C.	oxidation	substitution	condensation
D.	substitution	oxidation	substitution

37. Which of the following pairs are members of the same homologous series?

A. $CH_3CH_2CH_2OH$ and CH_3CH_2CHO

B. $CH_3CH(OH)CH_3$ and $CH_3CH_2CH(OH)CH_3$

C. CH_3COCH_3 and CH_3CH_2COOH

D. $CH_3COCH_2CH_3$ and CH_3CH_2CHO

38. Which of the following statements about alkenes is **not** correct?

A. They have reactive double bonds.

B. They can form addition polymers.

C. They react mainly by substitution.

D. They can react with water to form alcohols.

39. What is the type of mechanism and an important feature of the reaction between $C(CH_3)_3Br$ and aqueous NaOH?

	Mechanism	Feature
A.	S_N1	a transition state
B.	S_N1	an intermediate
C.	S_N2	a transition state
D.	S_N2	an intermediate

40. A burette reading is recorded as 27.70 ± 0.05 cm^3. Which of the following could be the actual value?

I. 27.68 cm^3

II. 27.78 cm^3

III. 27.74 cm^3

A. I and II only

B. I and III only

C. II and III only

D. I, II and III