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CHEMISTRY
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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. What is the total number of hydrogen atoms in 1.0 mol of benzamide, $C_6H_5CONH_2$?

A. 7

B. 6.0×10^{23}

C. 3.0×10^{24}

D. 4.2×10^{24}

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

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

What is the amount, in mol, of H_2O produced when 10.0 mol of C_2H_3Cl and 10.0 mol of O_2 are mixed together, and the above reaction goes to completion?

A. 4.00

B. 8.00

C. 10.0

D. 20.0

3. What is the concentration of NaCl, in $mol\,dm^{-3}$, when 10.0 cm^3 of 0.200 $mol\,dm^{-3}$ NaCl solution is added to 30.0 cm^3 of 0.600 $mol\,dm^{-3}$ NaCl solution?

A. 0.450

B. 0.300

C. 0.500

D. 0.800

4. Consider the relative abundance of the isotopes of element X.

Isotope	Relative abundance (%)
^{24}X	80
^{25}X	10
^{26}X	10

What is the relative atomic mass of X?

A. 24

B. 25

C. Between 24 and 25

D. Between 25 and 26

5. In the emission spectrum of hydrogen, which electronic transition would produce a line in the visible region of the electromagnetic spectrum?

A. $n = 2 \rightarrow n = 1$

B. $n = 3 \rightarrow n = 2$

C. $n = 2 \rightarrow n = 3$

D. $n = \infty \rightarrow n = 1$

6. Values for the successive ionization energies for an unknown element are given in the table below.

First ionization energy / kJ mol^{-1}	Second ionization energy / kJ mol^{-1}	Third ionization energy / kJ mol^{-1}	Fourth ionization energy / kJ mol^{-1}
420	3600	4400	5900

In which group of the periodic table would the unknown element be found?

A. 1

B. 2

C. 3

D. 4

7. Which pair of elements has the greatest difference in electronegativity?

A. Cs and F

B. Cs and Cl

C. Cs and Br

D. Cs and I

8. Ligands can form dative covalent bonds with metal ions to form complex ions. Which of the following can act as a ligand?

I. Cl^-

II. NH_3

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. Which metal nitrate solution is coloured?

A. $Zn(NO_3)_2(aq)$

B. $Ni(NO_3)_2(aq)$

C. $Mg(NO_3)_2(aq)$

D. $Sc(NO_3)_3(aq)$

10. When C_2H_2, C_2H_4 and C_2H_6 are arranged in order of **increasing** carbon-carbon bond strength (weakest bond first), what is the correct order?

A. C_2H_2, C_2H_4, C_2H_6

B. C_2H_2, C_2H_6, C_2H_4

C. C_2H_6, C_2H_4, C_2H_2

D. C_2H_6, C_2H_2, C_2H_4

11. Which molecule has a non-bonding (lone) pair of electrons around the central atom?

A. BF_3

B. SO_2

C. PCl_5

D. SiF_4

12. Which particles are responsible for the conduction of electricity in molten aluminium?

A. Cations

B. Anions

C. Electrons

D. Protons

13. How many sigma and pi bonds are there in propyne, CH_3CCH?

A. 2 sigma and 2 pi

B. 7 sigma and 1 pi

C. 6 sigma and 2 pi

D. 5 sigma and 3 pi

14. Which species does **not** have delocalized electrons?

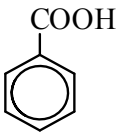
A. NO_3^-

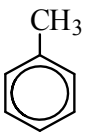
B. NO_2^-

C. O_3

D. C_3H_6

15. In which compound are all the carbon atoms sp^2 hybridized?

A. 

B. 

C. CH_2CHCH_3

D. $CH_3CH_2CHCHCH_2CH_3$

16. Which ionic compound has the greatest lattice enthalpy?

A. MgO

B. CaO

C. NaF

D. KF

17. Which equation represents the bond enthalpy for the H–Br bond in hydrogen bromide?

A. $HBr(g) \rightarrow H(g) + Br(g)$

B. $HBr(g) \rightarrow H(g) + Br(l)$

C. $HBr(g) \rightarrow H(g) + \frac{1}{2}Br_2(l)$

D. $HBr(g) \rightarrow H(g) + \frac{1}{2}Br_2(g)$

18. Which change will **not** increase the entropy of a system?

A. Increasing the temperature

B. Changing the state from liquid to gas

C. Mixing different types of particles

D. A reaction where four moles of gaseous reactants changes to two moles of gaseous products

19. $\Delta G^{\ominus}$ calculations predict that a reaction is always spontaneous for which of the following combinations of $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$?

A. $+\Delta H^{\ominus}$ and $+\Delta S^{\ominus}$

B. $+\Delta H^{\ominus}$ and $-\Delta S^{\ominus}$

C. $-\Delta H^{\ominus}$ and $-\Delta S^{\ominus}$

D. $-\Delta H^{\ominus}$ and $+\Delta S^{\ominus}$

20. Sodium carbonate and hydrochloric acid react according to the equation below.

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow CO_2(g) + 2NaCl(aq) + H_2O(l)$$

Which conditions will produce the fastest initial rate with 2.0 g of powdered sodium carbonate?

A. 100 cm^3 of 1.0 $mol\,dm^{-3}$ hydrochloric acid at 323 K

B. 50 cm^3 of 2.0 $mol\,dm^{-3}$ hydrochloric acid at 323 K

C. 100 cm^3 of 1.0 $mol\,dm^{-3}$ hydrochloric acid at 348 K

D. 50 cm^3 of 2.0 $mol\,dm^{-3}$ hydrochloric acid at 348 K

21. The rate information below was obtained for the following reaction at a constant temperature.

$$2NO_2(g) + F_2(g) \rightarrow 2NO_2F(g)$$

$[NO_2]$ / $mol\,dm^{-3}$	$[F_2]$ / $mol\,dm^{-3}$	Rate / $mol\,dm^{-3}\,s^{-1}$
2.0×10^{-3}	1.0×10^{-2}	4.0×10^{-4}
4.0×10^{-3}	1.0×10^{-2}	8.0×10^{-4}
4.0×10^{-3}	2.0×10^{-2}	1.6×10^{-3}

What are the orders of the reaction with respect to NO_2 and F_2?

A. NO_2 is first order and F_2 is second order

B. NO_2 is second order and F_2 is first order

C. NO_2 is first order and F_2 is first order

D. NO_2 is second order and F_2 is second order

22. Consider the following reaction.

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

A proposed reaction mechanism is:

$$NO(g) + NO(g) \rightleftharpoons N_2O_2(g) \qquad \textit{fast}$$
$$N_2O_2(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g) \qquad \textit{slow}$$
$$N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g) \qquad \textit{fast}$$

What is the rate expression?

A. $\text{rate} = k[H_2][NO]^2$

B. $\text{rate} = k[N_2O_2][H_2]$

C. $\text{rate} = k[NO]^2[H_2]^2$

D. $\text{rate} = k[NO]^2[N_2O_2]^2[H_2]$

23. The reaction below represents the Haber process for the industrial production of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ}$$

The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important.

Which statement is correct?

A. A higher temperature would ensure a higher yield and a faster rate.

B. A lower pressure would ensure a higher yield at a lower cost.

C. A lower temperature would ensure a higher yield and a faster rate.

D. A higher pressure would ensure a higher yield at a higher cost.

24. Which combination of intermolecular forces, boiling point and enthalpy of vaporization is correct?

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

25. Which is **not** a conjugate acid-base pair?

A. HNO_3 and NO_3^-

B. CH_3COOH and CH_3COO^-

C. H_3O^+ and OH^-

D. HSO_4^- and SO_4^{2-}

26. The pH of a solution changes from pH = 2 to pH = 5. What happens to the concentration of the hydrogen ions during this pH change?

A. It decreases by a factor of 1000

B. It increases by a factor of 1000

C. It decreases by a factor of 100

D. It increases by a factor of 100

27. Based on information in the table below, which acid is the strongest?

	Acid	pK_a	K_a
A.	HA	2.0	–
B.	HB	–	1×10^{-3}
C.	HC	4.0	–
D.	HD	–	1×10^{-5}

28. Which combination will form a buffer solution?

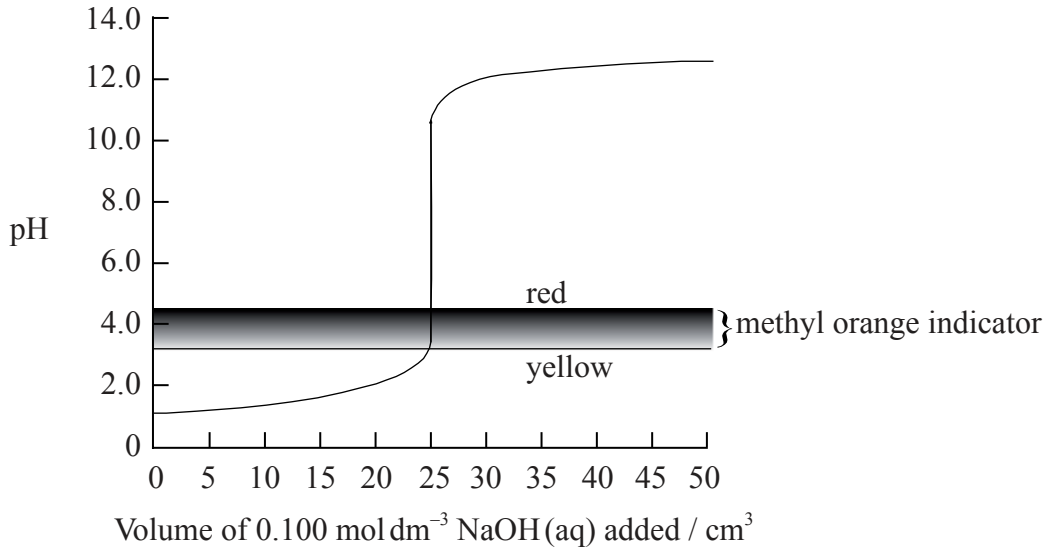
A. 100 cm^3 of 0.10 mol dm^{-3} hydrochloric acid with 50 cm^3 of 0.10 mol dm^{-3} sodium hydroxide.

B. 100 cm^3 of 0.10 mol dm^{-3} ethanoic acid with 50 cm^3 of 0.10 mol dm^{-3} sodium hydroxide.

C. 50 cm^3 of 0.10 mol dm^{-3} hydrochloric acid with 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide.

D. 50 cm^3 of 0.10 mol dm^{-3} ethanoic acid with 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide.

29. The graph below shows the titration curve of 25 cm^3 of 0.100 $mol\,dm^{-3}$ of hydrochloric acid with sodium hydroxide, of 0.100 $mol\,dm^{-3}$ concentration. The indicator methyl orange was used to determine the equivalence point. Methyl orange has a pH range of 3.2–4.4.



If the hydrochloric acid was replaced by ethanoic acid of the same volume and concentration, which property of the titration would remain the same?

A. The initial pH

B. The pH at the equivalence point

C. The volume of strong base, NaOH, needed to reach the equivalence point

D. The colour of the titration mixture just before the equivalence point is reached

30. What happens to iodine when iodate ions, IO_3^-, are converted to iodine molecules, I_2?

A. It undergoes reduction and its oxidation number changes from –1 to 0

B. It undergoes oxidation and its oxidation number changes from –1 to 0

C. It undergoes reduction and its oxidation number changes from +5 to 0

D. It undergoes oxidation and its oxidation number changes from +5 to 0

31. Consider the following reactions of three unknown metals X, Y and Z.

$$2XNO_3(aq) + Y(s) \rightarrow 2X(s) + Y(NO_3)_2(aq)$$
$$Y(NO_3)_2(aq) + Z(s) \rightarrow \text{No reaction}$$
$$2XNO_3(aq) + Z(s) \rightarrow 2X(s) + Z(NO_3)_2(aq)$$

What is the order of **increasing** reactivity of the metals (least reactive first)?

A. X < Y < Z

B. X < Z < Y

C. Z < Y < X

D. Y < Z < X

32. The standard electrode potentials for two metals are given below.

$$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s) \qquad E^\ominus = -1.66 \text{ V}$$
$$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s) \qquad E^\ominus = -0.23 \text{ V}$$

What is the equation and cell potential for the spontaneous reaction that occurs?

A. $2Al^{3+}(aq) + 3Ni(s) \rightarrow 2Al(s) + 3Ni^{2+}(aq)$ $E^\ominus = 1.89$ V

B. $2Al(s) + 3Ni^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$ $E^\ominus = 1.89$ V

C. $2Al^{3+}(aq) + 3Ni(s) \rightarrow 2Al(s) + 3Ni^{2+}(aq)$ $E^\ominus = 1.43$ V

D. $2Al(s) + 3Ni^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$ $E^\ominus = 1.43$ V

33. The same quantity of electricity was passed through separate molten samples of sodium bromide, NaBr, and magnesium chloride, $MgCl_2$. Which statement is true about the amounts, in mol, that are formed?

A. The amount of Mg formed is equal to the amount of Na formed.

B. The amount of Mg formed is equal to the amount of Cl_2 formed.

C. The amount of Mg formed is twice the amount of Cl_2 formed.

D. The amount of Mg formed is twice the amount of Na formed.

34. Which of the structures below is an aldehyde?

A. $CH_3CH_2CH_2CH_2OH$

B. $CH_3CH_2COCH_3$

C. $CH_3CH_2COOCH_3$

D. $CH_3CH_2CH_2CHO$

35. Which type of reaction occurs when 2-iodo-2-methylpropane, $C(CH_3)_3I$, reacts with aqueous sodium hydroxide, NaOH (aq)?

A. Addition

B. Free-radical substitution

C. S_N1

D. S_N2

36. Halogenoalkanes can undergo S_N1 and S_N2 reactions with aqueous sodium hydroxide. Which halogenoalkane will react fastest with a 0.1 mol dm^{-3} solution of aqueous sodium hydroxide?

A. 2-chloro-2-methylpropane

B. 2-iodo-2-methylpropane

C. 1-chlorobutane

D. 1-iodobutane

37. Propanitrile can be prepared by reacting bromoethane with potassium cyanide. Which statement is **not** correct about the reaction between bromoethane and potassium cyanide?

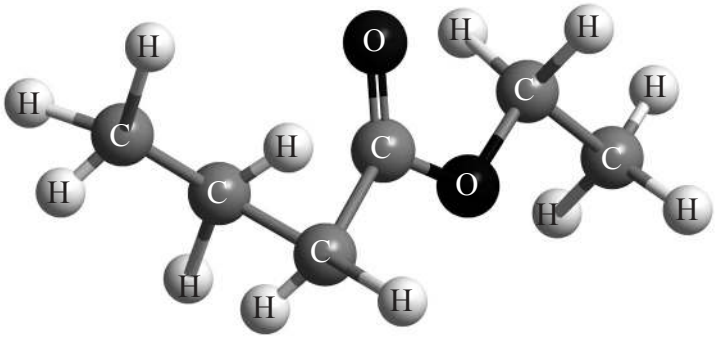
A. The reaction is bi-molecular.

B. The reaction follows the S_N2 mechanism.

C. Homolytic fission occurs between the carbon-bromine bond in bromoethane.

D. The cyanide ion, $:CN^-$, acts as a nucleophile.

38. Which reactants could be used to form the compound below?



A. Butanoic acid and ethanol

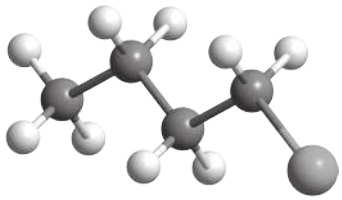
B. Propanoic acid and ethanol

C. Ethanoic acid and propan-1-ol

D. Ethanoic acid and butan-1-ol

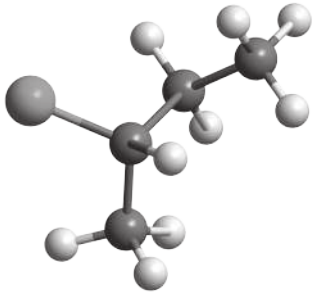
39. Which compound is optically active?

A.



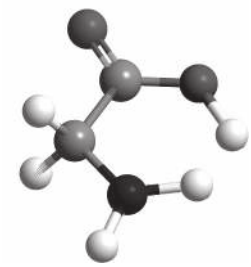
1-chlorobutane

B.



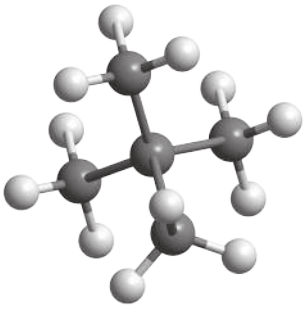
2-chlorobutane

C.



2-aminoethanoic acid

D.



2,2-dimethylpropane

40. A piece of metallic aluminium with a mass of 10.044 g was found to have a volume of 3.70 cm^3. A student carried out the following calculation to determine the density.

$$\text{Density (g cm}^{-3}\text{)} = \frac{10.044}{3.70}$$

What is the best value the student could report for the density of aluminium?

A. 2.715 g cm^{-3}

B. 2.7 g cm^{-3}

C. 2.71 g cm^{-3}

D. 2.7146 g cm^{-3}