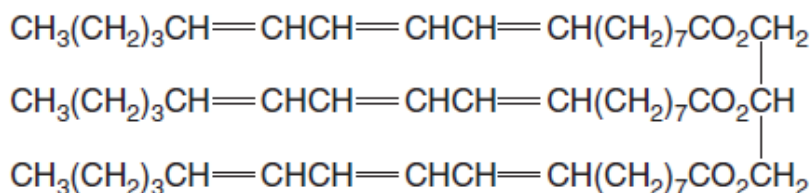


EXAMINATION SIMULATION

Section A

1. What is the number of molecules in 500 cm<sup>3</sup> of oxygen under room conditions?
  - a.  $1.25 \times 10^{22}$
  - b.  $1.34 \times 10^{22}$
  - c.  $3.0 \times 10^{22}$
  - d.  $3.0 \times 10^{26}$
2. In the preparation of soft margarine, glyceryl trieleostearate



is suitably hydrogenated so that, on average, one of its side-chains is converted into the  $\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{CO}_2$  residue and two side-chains are converted into the  $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CO}_2$  residue.

How many moles of hydrogen are required to convert one mole of glyceryl trieleostearate into the soft margarine?

- a. 4
  - b. 5
  - c. 6
  - d. 9
3. Which isotope of an element in the third period of the Periodic Table contains the same number of neutrons as  ${}_{16}^{32}\text{S}$  ?
    - a.  ${}_{11}^{23}\text{Na}$
    - b.  ${}_{12}^{24}\text{Mg}$
    - c.  ${}_{14}^{28}\text{Si}$
    - d.  ${}_{15}^{31}\text{P}$
  4. The successive ionisation energies, in  $\text{kJ mol}^{-1}$ , of an element X are given below.  
870    1800    3000    3600    5800    7000    13200  
What is X?
    - a.  ${}_{33}\text{As}$
    - b.  ${}_{40}\text{Zr}$
    - c.  ${}_{52}\text{Te}$
    - d.  ${}_{53}\text{I}$
  5. Which of the following solids has a simple molecular lattice?
    - a. Magnesium oxide
    - b. Sodium
    - c. Silicon (IV) oxide
    - d. Sulphur

6. Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the equation

$$pV = nRT$$

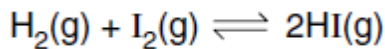
In order to calculate the  $M_r$  of the compound, Which conditions of pressure and temperature would give the most accurate value of  $M_r$ ?

- High pressure, low temperature
  - High pressure, low temperature
  - Low pressure, high temperature
  - Low pressure, low temperature
7. Gaseous phosphorus pentachloride can be decomposed into gaseous phosphorus trichloride and chlorine by heating. The table below gives the bond energies.

bond	bond energy / $\text{kJ mol}^{-1}$
P-Cl (in both chlorides)	330
Cl-Cl	240

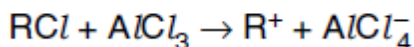
What is the enthalpy change in the decomposition of  $\text{PCl}_5$  to  $\text{PCl}_3$  and  $\text{Cl}_2$ ?

- $-420 \text{ kJmol}^{-1}$
  - $-90 \text{ kJmol}^{-1}$
  - $+90 \text{ kJmol}^{-1}$
  - $+420 \text{ kJmol}^{-1}$
8. When ammonia is converted into nitric acid on a commercial scale, the following reactions can occur. In which reaction does the greatest change in oxidation number of the nitrogen occur?
- $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$
  - $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$
  - $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$
  - $4\text{NH}_3 + 6\text{NO} \rightarrow 5\text{N}_2 + 6\text{H}_2\text{O}$
9. At the age of 17, in a woodshed in Ohio, Charles Martin Hall discovered the commercial process for the production of aluminium metal by the electrolysis of a mixture of bauxite,  $\text{Al}_2\text{O}_3$ , and cryolite,  $\text{Na}_3\text{AlF}_6$ . What is the main purpose of the cryolite?
- $\text{Al}_2\text{O}_3$  is covalent, and  $\text{AlF}_6^{-3}$  ions interact with it to produce  $\text{Al}^{3+}$  ions which can be discharged at the cathode.
  - Cryolite is a base, forming  $\text{NaAlO}_2$  with bauxite, enabling aluminium to be discharged at the anode.
  - Cryolite reduces the melting point of the bauxite.
  - Cryolite minimizes the release of  $\text{O}^{2-}$  ions at the graphite anodes, which are otherwise burnt away to CO.
10. When 0.20 mol of hydrogen gas and 0.15 mol of iodine gas are heated at 723 K until equilibrium is established, the equilibrium mixture is found to contain 0.26 mol of hydrogen iodide. The equation for the reaction is as follows.



What is the correct expression for the equilibrium constant  $K_c$ ?

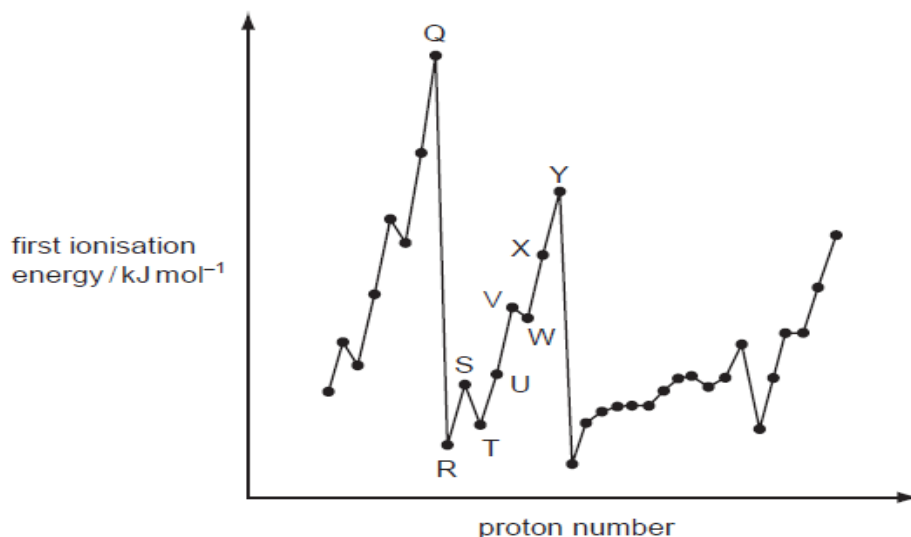
- a.  $\frac{2 \times 0.26}{0.20 \times 0.15}$   
b.  $\frac{(2 \times 0.26)^2}{0.20 \times 0.15}$   
c.  $\frac{0.26^2}{0.07 \times 0.02}$   
d.  $\frac{0.26^2}{0.13 \times 0.13}$
11. Why is ethanoic acid a stronger acid in liquid ammonia than in aqueous solution?
- Ammonia is a stronger base than water.
  - Ammonium ethanoate is completely ionised in aqueous solution.
  - Ammonium ethanoate is strongly acidic in aqueous solution.
  - Liquid ammonia is a more polar solvent than water.
12. It is often said that the rate of a typical reaction is roughly doubled by raising the temperature by 10°C. What explains this observation?
- Raising the temperature by 10°C doubles the average energy of each molecule.
  - Raising the temperature by 10°C doubles the average velocity of the molecules.
  - Raising the temperature by 10°C doubles the number of molecular collisions in a given time.
  - Raising the temperature by 10°C doubles the number of molecules having more than a certain minimum energy.
13. A mixture of the oxides of two elements of the third period is dissolved in water. The solution is approximately neutral. What could be the constituents of the mixture?
- Al<sub>2</sub>O<sub>3</sub> and MgO
  - Na<sub>2</sub>O and MgO
  - Na<sub>2</sub>O and P<sub>4</sub>O<sub>10</sub>
  - SO<sub>3</sub> and P<sub>4</sub>O<sub>10</sub>
14. Aluminium chloride catalyses certain reactions by forming carbocations (carbonium ions) with chloroalkanes as shown.



Which property makes this reaction possible?

- AlCl<sub>3</sub> is a covalent molecule.
  - AlCl<sub>3</sub> exists as the dimer Al<sub>2</sub>Cl<sub>6</sub> in the vapour.
  - The aluminium atom in AlCl<sub>3</sub> has an incomplete octet of electrons.
  - The chlorine atom in RCl has a vacant p orbital.
15. What are the products of the thermal decomposition of magnesium nitrate?
- magnesium nitride and oxygen
  - magnesium oxide and nitrogen
  - magnesium oxide, nitrogen and oxygen
  - magnesium oxide, nitrogen dioxide and oxygen

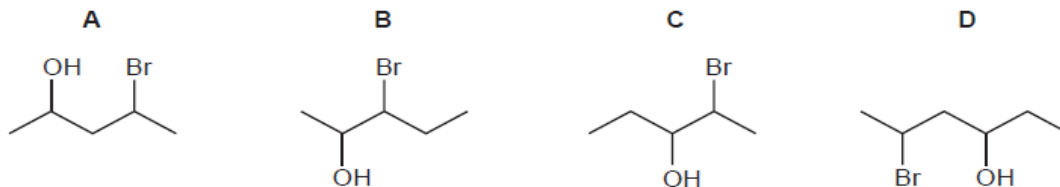
16. Carbon, nitrogen and sulfur are non-metals.  
Which statement about their oxides,  $XO_2$ , is correct? (Where X represents carbon, nitrogen or sulfur.)
- All of the  $XO_2$  molecules are linear.
  - In  $XO_2$ , each element has its highest oxidation number.
  - All  $XO_2$  molecules dissolve in water to form dibasic acids.
  - All  $XO_2$  molecules are formed as a result of burning petrol in a car engine.
17. Which oxide is insoluble in aqueous sodium hydroxide?
- MgO
  - $Al_2O_3$
  - $P_4O_{10}$
  - $SO_2$
18. The graph below shows the variation of the first ionisation energy with the number of protons for some elements.



Which statement is correct?

- Elements Q and Y are in the same period in the Periodic Table.
  - The general increase from elements R to Y is due to increasing atomic radius.
  - The small decrease between elements S and T is due to decreased shielding.
  - The small decrease between elements V and W is due to repulsion between paired electrons.
19. Elements J and K react together to form compound L. Elements J and K are both in Period 3. Element J has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element K. Which compound could be L?
- $MgCl_2$
  - MgS
  - $Na_2S$
  - $PCl_3$

20. Which compound will be formed when pentan-2,4-diol is treated with HBr?



21. Including structural and stereoisomers, how many isomers are there of  $C_2H_2Br_2$ ?

- 2
- 3
- 4
- 5

22. Which reaction will give the best yield of 2-chloropropane?

- chlorine gas with propane gas in the presence of uv light
- chlorine gas with propene gas in the dark
- propan-2-ol with dilute NaCl (aq)
- propan-2-ol with  $PCl_5$

23. Pent-2-ene reacts in a similar way to ethene. Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions. What will be produced in the greatest amount?

- $CH_3CH_2CH(OH)CH(OH)CH_3$
- $CH_3CH_2COCOCH_3$
- a mixture of  $CH_3CH_2CH(OH)CH_2CH_3$  and  $CH_3CH_2CH_2CH(OH)CH_3$
- $CH_3CH_2COOH$  and  $CH_3COOH$

24. Including structural and stereoisomers, how many isomeric products are produced when alcoholic KOH reacts with 2-chlorobutane?

- 1
- 2
- 3
- 4

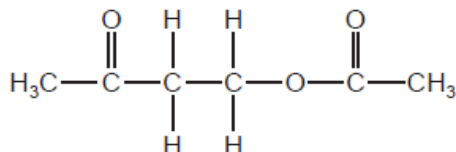
25. Chlorofluorocarbons, CFCs, can be used as refrigerants, aerosol propellants and fire extinguishers. CFCs such as  $CCl_3F$  and  $CCl_2F_2$  are more stable than chloroalkanes such as  $CCl_4$ . What is the reason for their greater stability?

- Fluorine has higher first ionisation energy than chlorine.
- Fluorine radicals are more stable than chlorine radicals.
- The C–F bond energy is larger than the C–Cl bond energy.
- The C–F bond is more polar than the C–Cl bond.

26. Halogenoalkanes react with aqueous NaOH to give alcohols. The mechanism involved is either  $S_N1$  or  $S_N2$ . Which halogenoalkane produces the highest percentage of product by an  $S_N1$  mechanism, when treated with aqueous NaOH?

- 2-bromopropane
- 2-chloropropane
- 1-iodo-2-methylpropane
- 2-iodo-2-methylpropane

27. An alcohol with molecular formula  $C_nH_{2n+1}OH$  has a chiral carbon atom but does not react with hot, acidified  $K_2Cr_2O_7$ . What is the smallest possible value for  $n$ ?
- 5
  - 6
  - 7
  - 8
28. Compound X reacts with ethanoic acid in the presence of an  $H^+$  catalyst to produce the compound below.

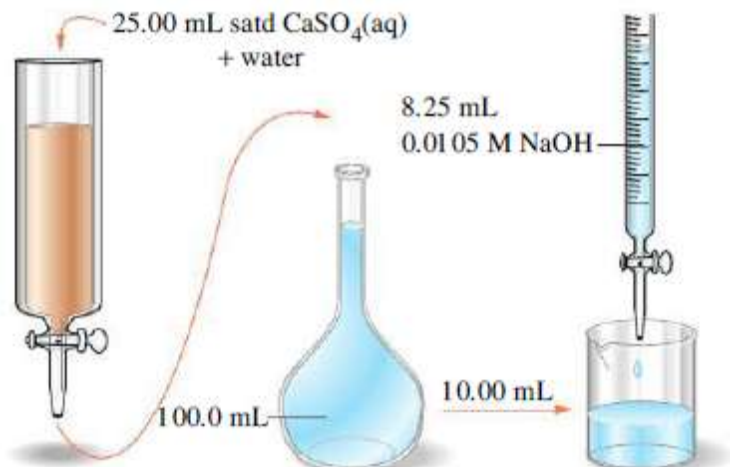


What is the molecular formula of compound X?

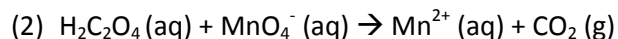
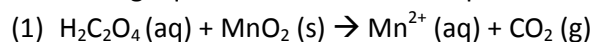
- $C_2H_6O_2$
  - $C_2H_6O_3$
  - $C_4H_8O$
  - $C_4H_8O_2$
29. How many hydrogen atoms are added to each molecule of ethanal when it is reacted with  $NaBH_4$  in water?
- 1
  - 2
  - 4
  - 6
30. Which fragment could appear in the chain produced by polymerising 1,1-dichloroethene?
- $-CH_2-CH_2-CCl_2-CCl_2-CH_2-CH_2-$
  - $-CHCl-CHCl-CHCl-CHCl-CHCl-CHCl-$
  - $-CH_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$
  - $-CCl_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

#### Section B

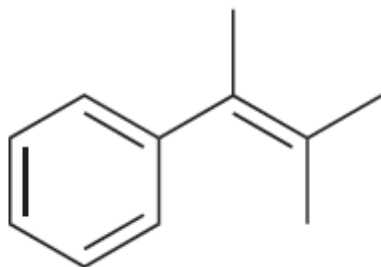
- From the observation that 0.0500 M vinylacetic acid has a freezing point of  $-0.096^\circ C$ , determine  $K_a$  for this acid.  
 $CH_2=CHCH_2CO_2H + H_2O \leftrightarrow H_3O^+ + CH_2=CHCH_2CO_2^-$
- In an experiment to measure  $K_{sp}$  of  $CaSO_4$  [D. Masterman, J. Chem. Educ., 64, 409 (1987)], a saturated solution of  $CaSO_4$  (aq) is poured into the ion-exchange column pictured. As the solution passes through the column,  $Ca^{2+}$  is retained by the ion-exchange medium and  $H_3O^+$  is released; two  $H_3O^+$  ions appear in the effluent solution for every  $Ca^{2+}$  ion. As the drawing suggests, a 25.00 mL sample is added to the column, and the effluent is collected and diluted to 100.0 mL in a volumetric flask. A 10.00 mL portion of the diluted solution requires 8.25 mL of 0.0105 M NaOH for its titration. Use these data to obtain a value of  $K_{sp}$  for  $CaSO_4$ .



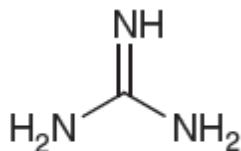
3. A 0.589 g sample of pyrolusite ore (impure  $\text{MnO}_2$ ) is treated with 1.651 g of oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ ) in an acidic medium (reaction 1). Following this, the excess oxalic acid is titrated with 30.06 mL of 0.1000 M  $\text{KMnO}_4$  (reaction 2). What is the mass percent of  $\text{MnO}_2$  in the pyrolusite? The following equations are neither complete nor balanced.



4. When 3-methyl-3-phenyl-1-butanamine is treated with sodium nitrite and HCl, a mixture of products is obtained. The following compound was found to be present in the reaction mixture. Account for its formation with a complete mechanism (make sure to show the mechanism of formation for a nitrosonium ion).



5. Guanidine lacks a negative charge but is an extremely powerful base. In fact, it is almost as strong a base as a hydroxide ion. Identify which nitrogen atom in guanidine is so basic and explain why guanidine is a much stronger base than most other amines.



Guanidine