

Chemistry

SY I

1977

CERTIFICATE OF SIXTH YEAR STUDIES

CHEMISTRY

Paper



Dalziel High School
Chemistry Department

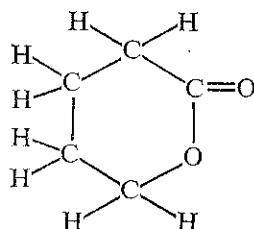


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1. The group of radiations arranged in order of **increasing** wavelength is
- A X-ray, infra-red, ultra-violet; radio
 - B infra-red, ultra-violet, X-ray, gamma
 - C ultra-violet, visible, infra-red, radio
 - D radio, infra-red, visible, gamma.
2. If there was a strike which caused a halt in sulphuric acid production, which of the following industries would be **least** likely to be affected?
Manufacture of
- A phosphatic fertilisers
 - B detergents
 - C nitric acid
 - D hydrofluoric acid.

3. In which of the following classes would you place the compound shown below?



- A Ketone (alkanone)
 - B Ether
 - C Ester
 - D Phenol
4. In which of the following changes does the metal involved undergo oxidation?
- A $\text{MnO}_4^{2-} \rightarrow \text{MnO}_2$
 - B $\text{Co}(\text{NH}_3)_6^{3+} \rightarrow \text{Co}(\text{NH}_3)_6^{2+}$
 - C $\text{Fe}(\text{CN})_6^{3-} \rightarrow \text{Fe}(\text{CN})_6^{4-}$
 - D $\text{VO}^{2+} \rightarrow \text{VO}_2^+$
5. Given that the dissociation constant, K_a , of 3-chloropropanoic acid is 1.0×10^{-4} , ethanoic acid 1.8×10^{-5} , and hydrocyanic acid 4.9×10^{-10} , it can be said that
- A 0.01 M ethanoic acid is more highly ionised than 0.01 M 3-chloropropanoic acid
 - B 0.01 M 3-chloropropanoic acid is the poorest electrical conductor of the three
 - C 0.01 M solutions of all three acids have pH less than 3
 - D hydrocyanic acid is the weakest acid of the three.

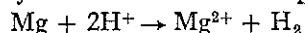
6. $\text{Mg(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{MgSO}_4(\text{aq}) + \text{H}_2(\text{g}) \quad \Delta H = X \text{ kJ mol}^{-1}$
 $\text{Zn(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{H}_2(\text{g}) \quad \Delta H = Y \text{ kJ mol}^{-1}$
 $\text{Mg(s)} + \text{ZnSO}_4(\text{aq}) \rightarrow \text{Zn(s)} + \text{MgSO}_4(\text{aq}) \quad \Delta H = Z \text{ kJ mol}^{-1}$

For Hess's Law to hold

- A $X = Y + Z$
B $Y = X + Z$
C $Z = X + Y$
D $0 = X + Y + Z$
7. Metallic silver can be obtained from ammoniacal silver nitrate solution by the addition of certain organic compounds. Which of the following is likely to bring this about?
- A Ethyl ethanoate
B Glucose
C Acetone (propan-2-one)
D Ethanol
8. On electrolysis of dilute sulphuric acid, 11.2 litres of gas at s.t.p. were liberated at the negative electrode. Which of the following is true?
- A Half a mole of hydrogen atoms were liberated.
B Half a mole of hydrogen molecules were liberated.
C Half a mole of oxygen molecules were liberated.
D Half a mole of oxygen atoms were liberated.
9. Which molecule is likely to produce the most stable organic ion in an hydrolysis reaction?
- A $(\text{CH}_3)_3\text{CCl}$
B $\text{CH}_3\text{CH}_2\text{Br}$
C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{Br}$
D $\text{CH}_3\text{CH}_2\text{I}$
10. The activity of tritium (half-life 12.4 years) trapped in a sample of ice, was found to be 0.062 times that in fresh snow.
Approximately how old was the ice sample?
- A 12.4×0.062 years
B 6.2 years
C 16 years
D 50 years

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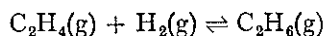
11. The action of magnesium metal on dilute hydrochloric acid can be represented by the equation



When excess magnesium is added to 500 ml of dilute hydrochloric acid 1 mole of hydrogen gas is produced. What is the molarity of the hydrochloric acid?

- A 0.5
- B 1
- C 2
- D 4

12. The following reversible system might be used to obtain unsaturated compounds from saturated ones.

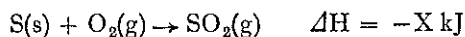


For the reaction from left to right $\Delta H = -157 \text{ kJ mol}^{-1}$

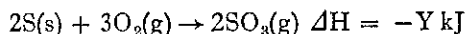
Which one of the following sets of conditions would lead to the best yield of ethene (C_2H_4)?

- A High pressure; high temperature
- B High pressure; low temperature
- C Low pressure; high temperature
- D Low pressure; low temperature

13. Given the following information



and



what is ΔH (in kJ) for the reaction



- A $2X - Y$
- B $\frac{2X - Y}{2}$
- C $Y - 2X$
- D $\frac{Y - 2X}{2}$

14. In which of the following reactions would you expect to find the greatest entropy decrease?

- A $\text{CO}_3^{2-}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HCO}_3^-(\text{aq})$
- B $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- C $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
- D $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

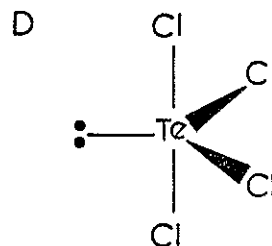
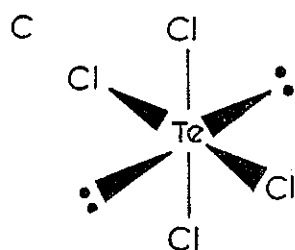
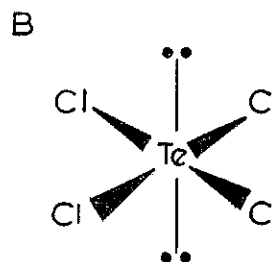
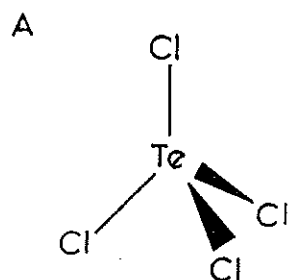
15. Which of the reactions, characterised by the following standard enthalpy and entropy changes, is **not** spontaneous at any temperature?

ΔH (kJ mol ⁻¹)	ΔS (J K ⁻¹ mol ⁻¹)
A +30.0	+28.2
B +1.3	-21
C -46.2	-199.1
D -315.0	+55.1

16. The energy of a photon (quantum of electromagnetic radiation) is directly proportional to

- A the frequency of the radiation
- B the wavelength of the radiation
- C the velocity of the radiation
- D the reciprocal of the wave number.

17. Tellurium has six binding electrons in its outer shell. Which of the following shows the shape of the TeCl_4 molecule? (: denotes a lone pair of electrons).



Questions 18 and 19 refer to the following data at 25 °C for the theoretical dissolution of the chloride and fluoride of a metal X

Reaction	ΔH (kJ mol ⁻¹)	$T\Delta S$ (kJ mol ⁻¹)
$XCl_2(s) \rightarrow X^{2+}(aq) + 2Cl^{-}(aq)$	-84.0	-17.6
$XF_2(s) \rightarrow X^{2+}(aq) + 2F^{-}(aq)$	+12.6	-43.3

18. Which of the following is a correct prediction about the solubility of the salts in water at 25 °C?

	X chloride	X fluoride
A	insoluble	insoluble
B	soluble	soluble
C	insoluble	soluble
D	soluble	insoluble

19. The value of ΔH for the dissolution of the chloride tells us that

- A the formation of the chloride from its elements is an endothermic process
- B the sum of the Heats of Hydration of its ions exceeds the lattice energy of the chloride
- C the Ionisation Energy of X is lower than the Electron Affinity of chlorine
- D the dissociation of the crystalline chloride to form free ions is an exothermic process.

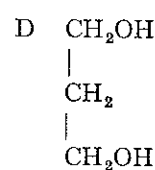
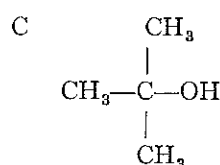
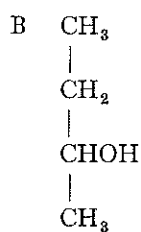
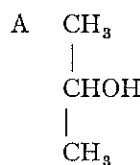
20. On the basis of d → d transitions, which of the following hydrated transition metal ions is most likely to be colourless?

- A Cr²⁺
- B Ti³⁺
- C V⁴⁺
- D Ti⁴⁺

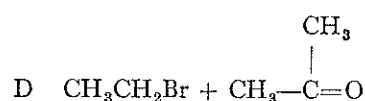
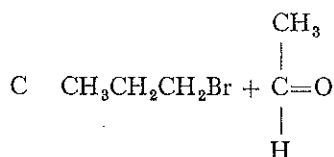
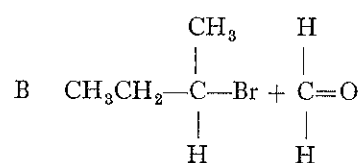
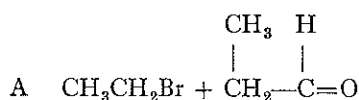
21. The position of the spots relative to the transmitted beam in an X-ray diffraction pattern is **not** affected by

- A the frequency of the X-rays
- B the coordination number of neighbours round each atom
- C the number of electrons on each atom
- D the distance between nearest neighbour atoms.

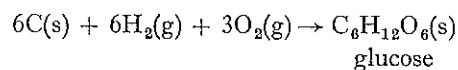
22. The vapour of an alcohol was passed over heated copper(II) oxide, forming an acid vapour. Which of the following compounds would give this result?



23. To prepare an alcohol $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3\text{CH}_2\text{CH} \\ | \\ \text{CH}_2\text{OH} \end{array}$ by a Grignard synthesis which of the following sets of starting materials, with magnesium, would be required?



24. Consider the following reaction



$$\Delta H = -1250 \text{ kJ mol}^{-1}$$

$$\Delta G = -900 \text{ kJ mol}^{-1}$$

yet carbon, hydrogen and oxygen, kept together for a long time, form no glucose. This is because

- A ΔH is numerically greater than ΔG
- B the equilibrium constant for the reaction must be very small
- C the reaction must have a large activation energy
- D biochemical reactions can take place only in living cells.

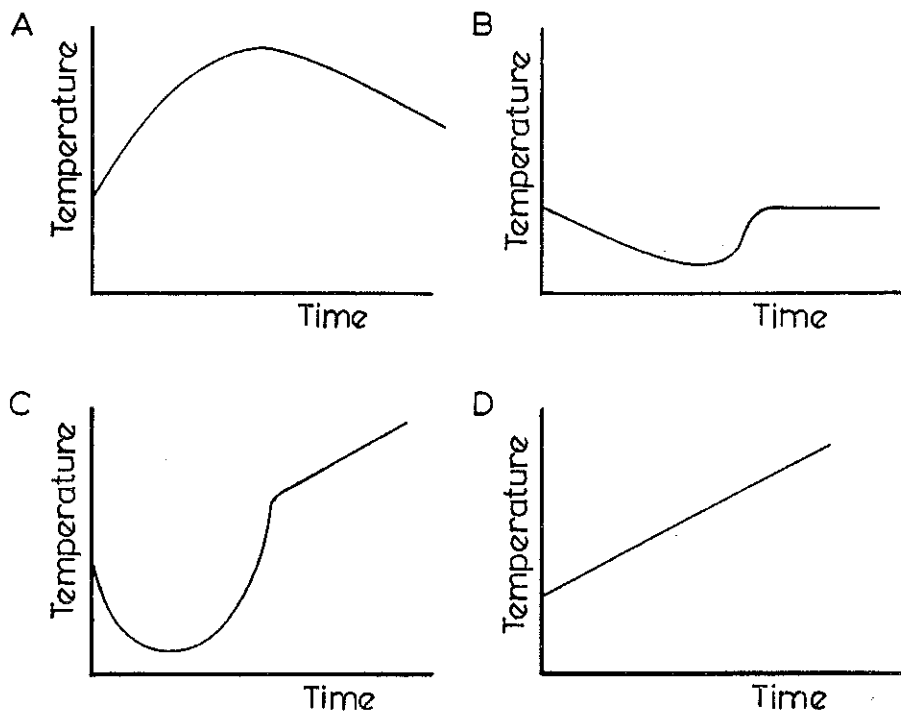
25. 25 ml of an aqueous solution of a salt shows little alteration in pH on addition of 1 ml 0.1 M hydrochloric acid or of 1 ml 0.1 M sodium hydroxide solution.

Which of the following salts might it be?

- A Sodium nitrate
- B Ammonium ethanoate
- C Lithium chloride
- D Potassium sulphate

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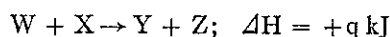
Questions 26, 27 and 28 refer to the following curves which show the temperature changes of a reaction mixture plotted against time.



Which of the above curves corresponds to each of the following processes?
(Note: A curve may be used more than once.)

26. The gradual addition of 100 ml M hydrochloric acid to 50 ml M sodium hydroxide.

27. The reaction represented by the equation



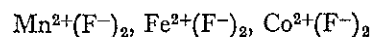
28. The gradual addition of sodium hydroxide pellets to a large volume of cold water.

29. $3\text{MnO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) \rightarrow 2\text{MnO}_4^-(\text{aq}) + \text{MnO}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l})$

Which of the following statements most fully describes what has happened to the oxidation state of manganese in the above reaction?

- A It has **not** been altered.
- B It has been lowered only.
- C It has been raised only.
- D It has been both lowered and raised.

30. The transition metal salts



have identical crystal structures despite varying numbers of 3d electrons because

- A they have similar nuclear charges
- B each transition metal has lost two electrons
- C the ions are all paramagnetic
- D the ions all have similar radii.

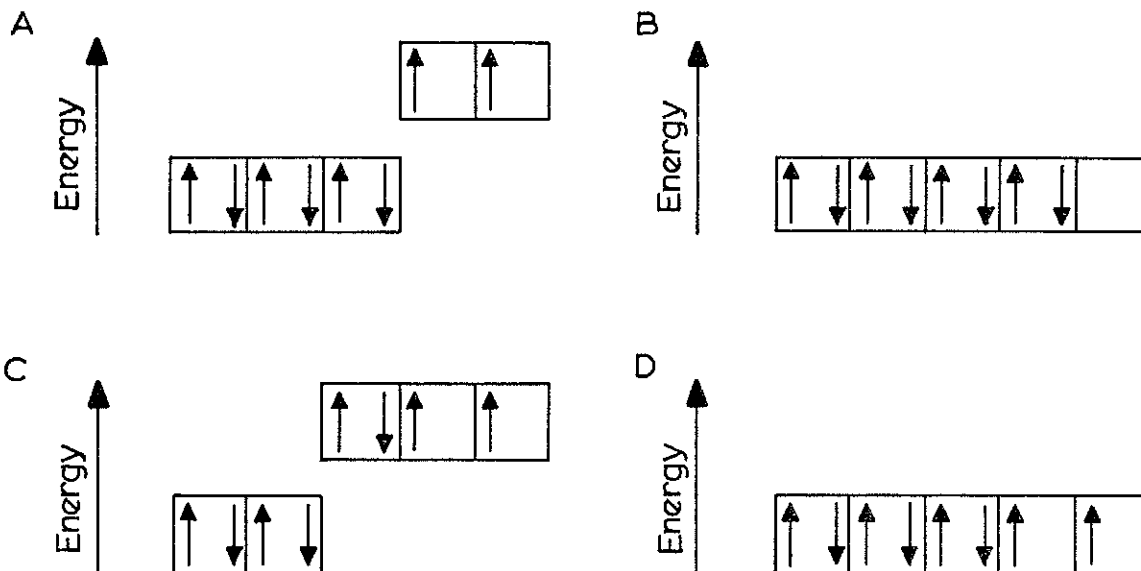
31. In which of the following is vanadium in the +4 oxidation state?

- A $\text{K}_2\text{VOF}_4 \cdot 2\text{H}_2\text{O}$
- B $\text{K}_4\text{VO}_3(\text{OH})$
- C $\text{K}_4\text{V}(\text{CN})_6$
- D K_3VO_4

32. Which one of the following would show the greatest degree of paramagnetism?

- A Cu $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$
- B $\text{Co}^{2+} 1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
- C $\text{Cu}^{2+} 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$
- D Ni $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

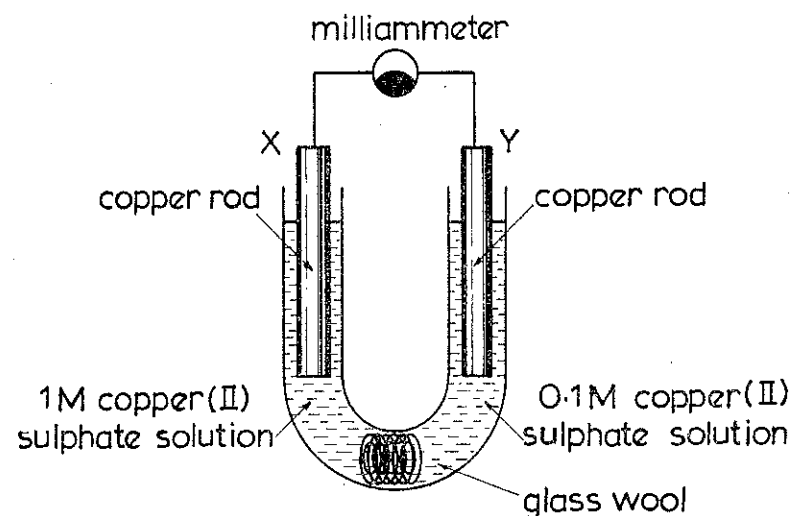
33.



Which of the above possible arrangements of the 3d electrons in the nickel(II) ion exists in the $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ ion?

[Turn over

34. Consider the diagram below.



Which of the following statements is correct?

- A At X copper ions are reduced, and electrons flow from X to Y through the milliammeter.
 - B At X copper atoms are oxidised and electrons flow from X to Y through the milliammeter.
 - C At Y copper ions are reduced, and electrons flow from Y to X through the milliammeter.
 - D At Y copper atoms are oxidised and electrons flow from Y to X through the milliammeter.
35. On heating an alcohol with acidified dichromate solution, the main product was a ketone with molecular formula C_4H_8O .

Which one of the following is the alcohol most likely to be?

- A


```

      H H H H
      | | | |
    H-C-C-C-C-H
      | | | |
      H H OH H
      
```
- B


```

      H H H H
      | | | |
    H-C-C-C-C-OH
      | | | |
      H H H H
      
```
- C


```

      H
      |
    H-C-H
      |
      H   |   H
      |   |   |
    H-C-C-C-OH
      |   |   |
      H   H   H
      
```
- D

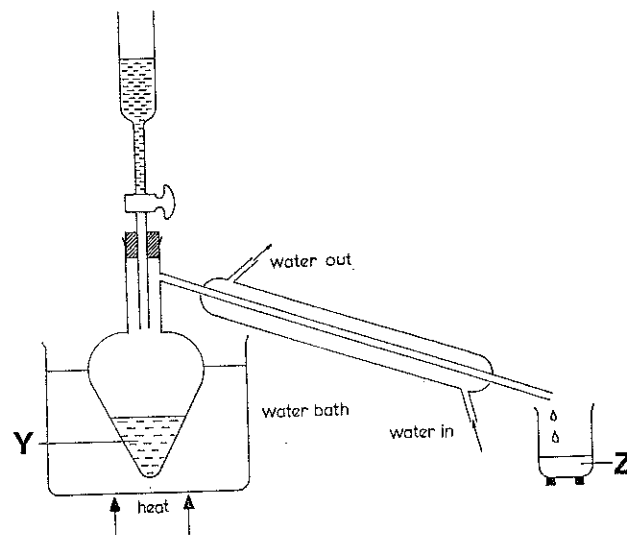

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      H
      |
    H-C-H
      |
      H   |   H
      |   |   |
    H-C-C-C-H
      |   |   |
      H   OH  H
      
```

36. Which of the following formulae represents 2-methylpentan-3-ol?

- A $\text{CH}_3\text{CH}(\text{CH}_3)\text{CHOHCH}_2\text{CH}_3$
- B $\text{CH}_3\text{CHOHCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CHOHCH}_3$
- D $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{CH}_2\text{OH}$

Questions 37 and 38 refer to the diagram below.



A student set up this apparatus in an attempt to prepare a few ml of reasonably pure propanoic acid by the oxidation of propan-1-ol. The latter was slowly introduced into the hot solution Y. The following information is available:

Compound	Formula	Boiling Point ($^{\circ}\text{C}$)
propan-1-ol	$\text{C}_3\text{H}_7\text{OH}$	97
propanal	$\text{C}_2\text{H}_5\text{CHO}$	49
propanoic acid	$\text{C}_2\text{H}_5\text{COOH}$	140
propan-2-one	$(\text{CH}_3)_2\text{C}=\text{O}$	56
propyl propanoate	$\text{C}_2\text{H}_5\text{COOC}_3\text{H}_7$	123

37. What should solution Y be?

- A Aqueous copper(II) solution
- B Aqueous iron(II) chloride solution
- C Acidified aqueous chromium(III) solution
- D Acidified aqueous chromium (VI) solution

38. The substance Z, which was collected, was **not** propanoic acid. Which of the following was the most likely product?

- A Propanal
- B Propan-1-ol
- C Propan-2-one
- D Propyl propanoate

[Turn over

39. In a mass spectrum which of the following could give a line at the same place as $[^{14}\text{N}^1\text{H}_2]^+$?
- A $[^{16}\text{O}_2]^+$
 - B $[^{28}\text{Si}^1\text{H}_3]^{2+}$
 - C $[^{14}\text{C}^1\text{H}_2]^{2+}$
 - D $[^7\text{Li}^1\text{H}]^{2+}$

Questions 40, 41 and 42 refer to the compounds A, B, C and D.

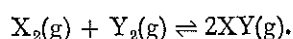
- A $\text{CH}_3\text{CHOHCH}_2\text{CH}_3$
- B $\text{CH}_3\text{COOCH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$
- D $\text{CH}_3\text{COH}(\text{CH}_3)\text{CH}_3$

Note that, in this set, the same compound may be the answer to more than one question.

Which of the above organic compounds

40. could be prepared by the reaction between ethanal and ethyl magnesium iodide?
41. is likely to have the lowest boiling point?
42. would be the main product of the action of ethoxide ions on bromoethane?
43. A compound has the formula C_6H_{12} .
On this fact **alone** what is the **most** information which can be concluded about the identity of the compound?
It is
- A a hydrocarbon
 - B an alkene
 - C a cycloalkane
 - D hexene.
44. 25 ml 1 M phosphoric acid (a triprotic or tribasic acid), on mixing with 50 ml 1 M ammonia solution, would produce a solution of
- A ammonium dihydrogen phosphate ($\text{NH}_4\text{H}_2\text{PO}_4$) and excess phosphoric acid
 - B ammonium dihydrogen phosphate ($\text{NH}_4\text{H}_2\text{PO}_4$) only
 - C diammonium hydrogen phosphate ($(\text{NH}_4)_2\text{HPO}_4$) only
 - D ammonium phosphate ($(\text{NH}_4)_3\text{PO}_4$) and excess ammonia.

45. Consider the equilibrium



For the reaction from left to right $\Delta\text{H} = -x \text{ kJ}$.

As the temperature of the mixture is increased which of the following statements will be true?

- A The rate of the reverse reaction will be increased by more than the rate of the forward reaction.
- B The rate of the forward reaction will be increased by more than the rate of the reverse reaction.
- C The rates of both forward and reverse reactions will be increased by the same amount.
- D No prediction is possible about relative increases in rates of forward and reverse reactions.

46. Which of the following formulae represents an aldehyde only?

- A C_3H_8O
- B C_2H_6O
- C C_2H_4O
- D CH_2O

To answer questions 47–50 use the following code:

If all responses 1, 2 and 3 are correct, select A.

If only 1 and 2 are correct, select B.

If only 3 is correct, select C.

If some other response, or combination of responses of those given, is correct, select D.

47. The change in enthalpy is positive in the reaction(s)

- 1. $H_2(g) \rightarrow 2H \cdot (g)$
- 2. $Na(g) \rightarrow Na^+(g) + e^-$
- 3. $Na^+(g) + H_2O \rightarrow Na^+(aq)$.

48. The following are descriptions of the behaviour of **both** carboxylate **and** sulphonate detergents:

- 1. They **both** reduce the surface tension of water.
- 2. They are **both** made ineffective by “hard” water.
- 3. They **both** help to keep oily dirt suspended in water.

49. Which of the following formulae may represent 2-methylpropanal?

- 1. $CH_3CH(CH_3)CHO$
- 2. $CH_3CH(CHO)CH_3$
- 3. CH_3COCH_3

50. In the following reactions increase in pressure increases the yield of the products:

- 1. $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$
- 2. $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$
- 3. $4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g)$

[END OF QUESTION PAPER]

1. (a) What is meant by the representations ΔG , ΔH and ΔS when applied to chemical reactions? (3)

(b) The values of ΔG , ΔH and ΔS for chemical reactions may be positive, negative or zero, depending on the conditions of the reactions.

What do the values (with signs) of ΔG , ΔH and ΔS tell about

(i) the likelihood of a reaction occurring,

(ii) heat changes within the reaction,

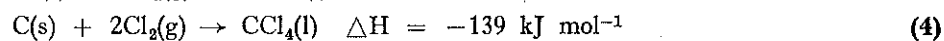
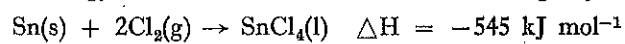
(iii) the relative states of reactants and products,

(iv) the reaction rate? (9)

(c) Offer explanations for the following statements:

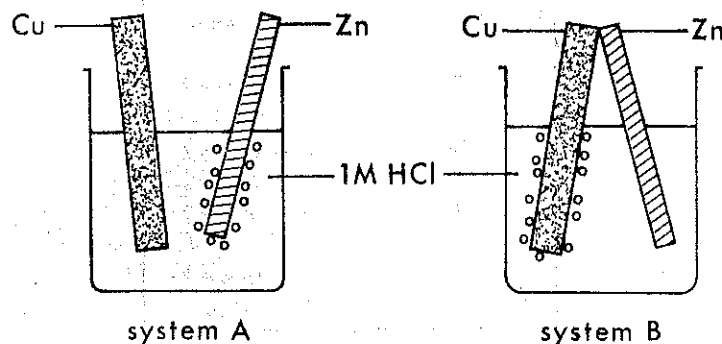
(i) "The thermal decomposition of calcium carbonate is accompanied by an increase in entropy yet the decomposition of calcium silicate has a negligible entropy change." (4)

(ii) "Bond energy values for Sn-Cl and C-Cl are almost equal yet:



2. (To assist you in answering this question you will require information on page 40 of the data book.)

- (a) Many oxidation-reduction reactions (redox reactions) take place in aqueous solution. State the nature of the redox reactions occurring in the systems shown below and account for the gas formation in each case.



- (b) If a voltaic cell is constructed from zinc and copper electrodes immersed in aqueous solutions of their respective ions, what would be
 (i) a balanced equation for the cell reaction,
 (ii) the e.m.f. value for the cell under standard conditions,
 (iii) the free energy change for the cell operating under standard conditions? (6)
- (c) Powdered tin in the presence of hydrochloric acid, is oxidised by potassium dichromate to tin(IV) chloride. (5)
- (i) Calculate the number of moles of tin oxidised by one mole of acidified dichromate solution. (3)
- (ii) Account for the relative oxidising properties of acidified dichromate and acidified permanganate solutions under standard conditions. (2)
- (d) Consider the equilibrium system below, the pH being such that both coloured ions are present:

$$2\text{CrO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightleftharpoons \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
yellow
orange
- (i) What would be observed with subsequent additions of
 (A) acid, (1)
 (B) alkali? (1)
- (ii) Show whether oxidation, reduction or neither occurs to chromium on addition of acid to the equilibrium system above. (2)

3. (a) "Hydrogen and chlorine exhibit identical bonding within their respective molecules." Discuss this statement. (4)
- (b) Spectroscopic analysis of elements provided early information on the structure of atoms. Balmer observed a series of lines in the visible atomic spectrum of hydrogen.

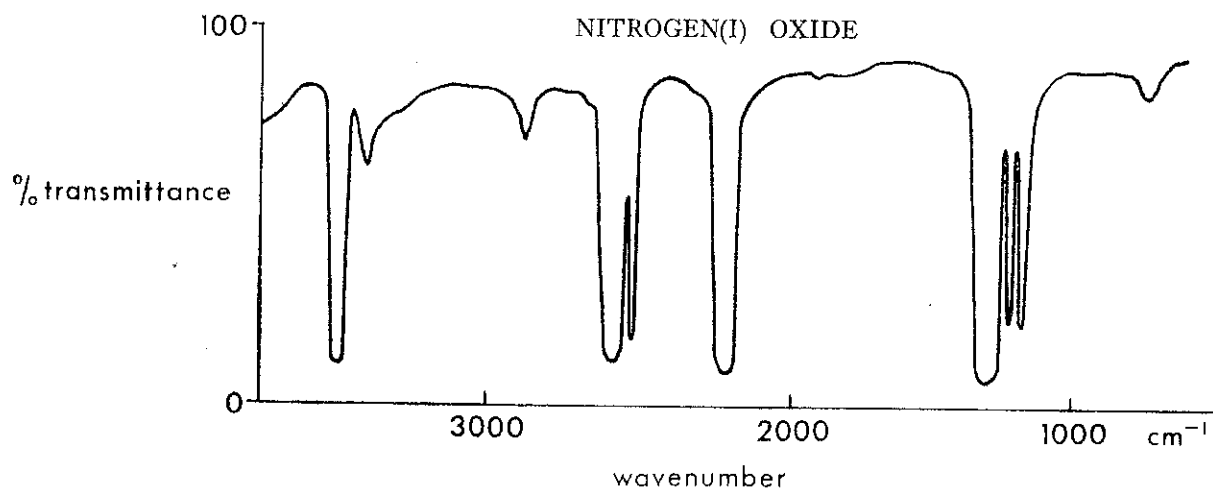
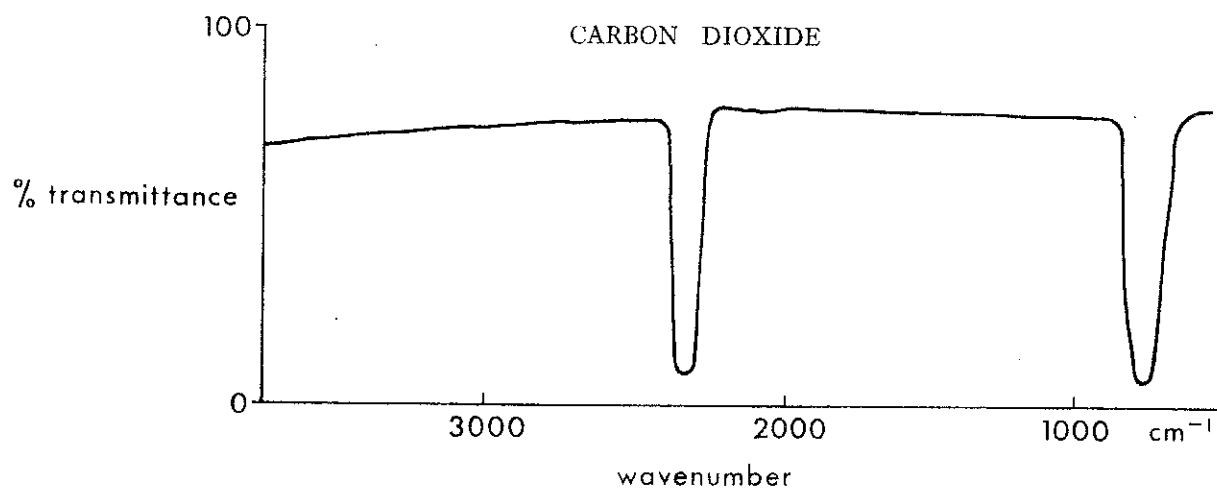
Main spectral lines (Balmer Series)

Wavelength (nm)	Transition
656	n = 3 to n = 2
486	n = 4 to n = 2
434	n = 5 to n = 2
410	n = 6 to n = 2

- (i) Explain what is meant by an "n to n" transition. (1)
- (ii) Offer an explanation for the formation of the lines. (2)
- (iii) Calculate the energy (in kJ mol^{-1}) associated with the line of lowest frequency in the Balmer Series. (3)
- (iv) Lyman observed another series of lines for atomic hydrogen in the ultra-violet region of the electro-magnetic spectrum. Account for this second series of lines. (2)
- (Use a diagram to illustrate your answer if necessary.)
- (c) CH_3CHO and CH_3COCH_3 show very similar absorptions both in the ultra-violet and the infra-red. (1)
- (i) Why? (1)
- (ii) What effects will the absorption of (A) ultra-violet radiation, (B) infra-red radiation, have on the bonds within these two molecules? (2)
- (iii) Suggest a reason why the ultra-violet spectrometer is evacuated for studies around wavelengths of 200 nm and below. (1)

Marks

- (d) Carbon dioxide and nitrogen(I) oxide are both linear triatomic molecules. The simplified infra-red spectra for these gases are given below.



Explain why the spectrum for nitrogen(I) oxide is more complicated than the spectrum for carbon dioxide.

(4)

[Turn over

Marks

5. Write an essay on "Silicon and its Compounds".

Your answer should include reference to the following points:

- (a) the physical and chemical properties of silicon;
- (b) similarities and differences of silicon compared with other elements of the same group;
- (c) the oxides, hydrides and halides of silicon;
- (d) the variety of structures in natural mineral silicates;
- (e) the chemical and industrial applications of mineral silicates;
- (f) chemical and commercial properties of silicones.

(20)

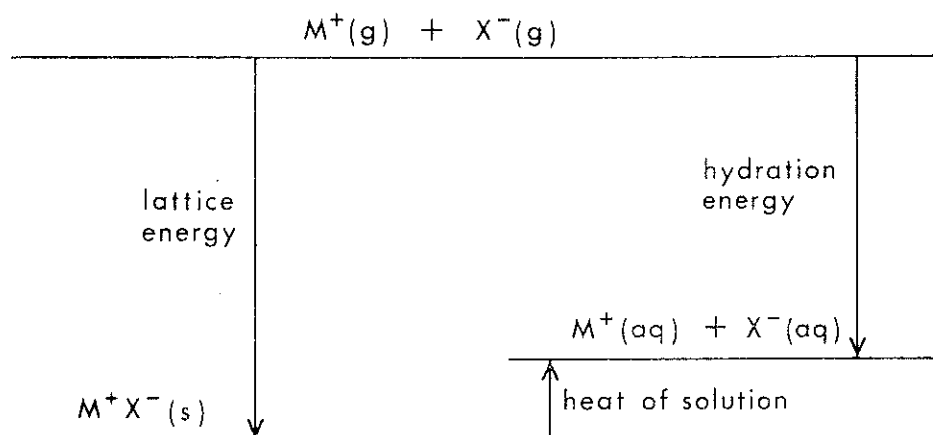
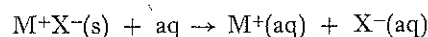
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6. (a) The Heats of Solution for sodium chloride and silver chloride are $+3.9 \text{ kJ mol}^{-1}$ and $+65.7 \text{ kJ mol}^{-1}$ respectively, at 298 K.

What do these values tell about the relative solubilities of the metal chlorides? (1)

- (b) In terms of the **processes** involved, suggest why ammonium chloride dissolves in water although the reaction is endothermic. (2)

- (c) The diagram below shows the enthalpy changes for the process



- (i) Use the following data to calculate hydration energies for sodium, potassium and rubidium chlorides:

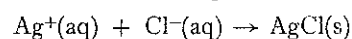
Compound	Lattice Energy (kJ mol^{-1})	Heat of Solution (kJ mol^{-1})
NaCl	-771.0	+3.9
KCl	-701.0	+17.2
RbCl	-675.0	+16.7

- (ii) What do the calculated values tell us about the trend in hydration energies for the ions of sodium, potassium and rubidium? (2)
- (iii) Suggest why lithium chloride is more soluble than sodium chloride, in water. (3)
- (iv) "Smaller ions may be expected to be more mobile in solution than larger ions." Comment on this statement with reference to the tabulated data below.

Aqueous ion	Li^+	Na^+	K^+
Molar Conductivity at 298 K ($\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$)	38.7	50.1	73.5

(2)

- (d) The determination of chloride according to



is one of the most accurate gravimetric analyses known.

- (i) **Outline** an experimental procedure to determine the concentration of chloride ion in a given aqueous solution. (4)
- (ii) Several experimental determinations of the percentage by weight of chlorine in the same batch of hydrated barium chloride, $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$, performed by a small group of students, produced the following results:

	% Chlorine in compound
Student A	32.3% ; 27.6% ; 46.4%
Student B	29.0% ; 29.1% ; 29.1%
Student C	22.2% ; 22.3% ; 22.3%

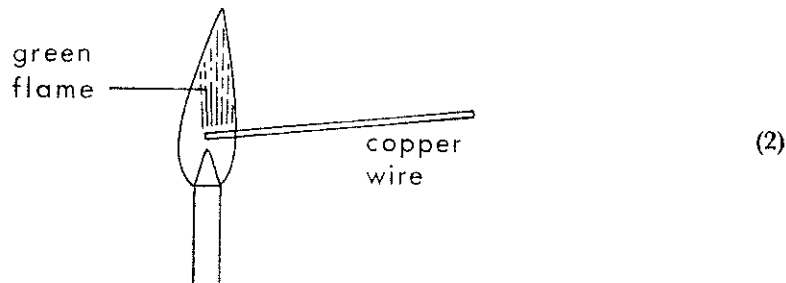
Comment on the degree of **accuracy** and **precision** of the experimental values obtained by each student. (3)

[Turn over

7. (a) Colour is observed in many chemical systems. Account for the colour phenomena in the cases below:

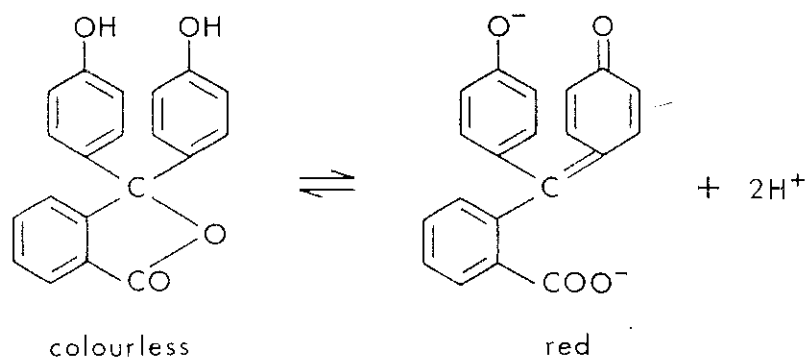
(i) Crystals of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ placed in concentrated H_2SO_4 . (2)

(ii)



(iii) The ion $\text{Ni}(\text{NH}_3)_6^{2+}$ is blue while $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ is green. (3)

(iv) Phenolphthalein, a sensitive acid-base indicator, exists in the equilibrium

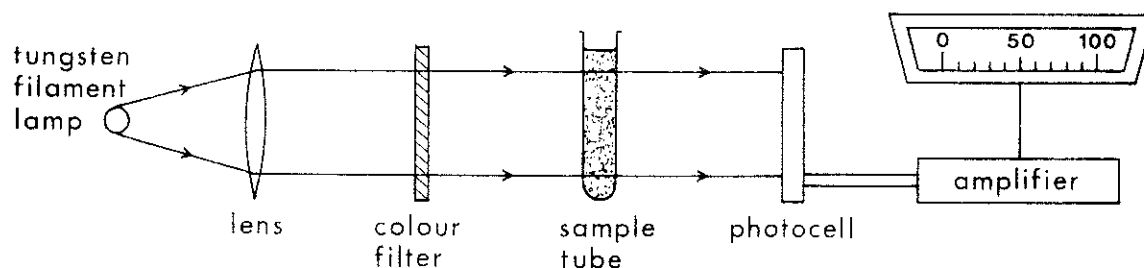


and is colourless in solutions of pH 8 or less. (2)

(v) Aqueous solutions of potassium tetraoxomanganate(VII) (potassium permanganate) are strong pink or purple. (2)

(b) The copper content of brass (an alloy of copper-zinc) may be estimated quantitatively in a colorimeter.

diagrammatic section through a colorimeter



5.3 g brass was dissolved in concentrated nitric acid and the solution was made up to one litre with water. A sample of this solution was then placed in the colorimeter.

7. (b) — continued

- (i) Give a **brief** outline of the operation of the colorimeter. (3)
- (ii) Measurements from the colorimeter indicated that the sample was 0.05 M with respect to copper(II) ions.
Calculate the composition of the brass. (**Show all your working.**) (3)
- (iii) Discuss whether you could use this method of analysis for accurate determination of the copper in coinage 'silver' which has the composition of 50% Ag, 40% Cu, 5% Ni and 5% Zn. (3)

8. (a) Zinc is treated in some chemical textbooks as a transition metal, being the next member of the series after copper.
- Discuss whether zinc should be considered a transition metal using the following properties:
- (i) variable oxidation state;
 - (ii) colour in compounds;
 - (iii) formation of complexes;
 - (iv) paramagnetism in compounds. (4)
- (b) State the oxidation state of iron in
- (i) K_4FeF_6
 - (ii) $FeCr_2O_4$
 - (iii) $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ (3)
- (c) Discuss, in terms of electron arrangement, reasons for the relative stabilities of iron(II) and iron(III) oxidation states. (3)
- (d) K_4FeF_6 is a paramagnetic compound, while $K_4Fe(CN)_6$ is diamagnetic.
- (i) How are these two properties distinguished experimentally? (2)
 - (ii) Account for the magnetic properties using d-orbital energy level diagrams. (5)
- (e) Suggest why liquid oxygen is paramagnetic and describe how this contradicts the simple theory of covalent bonding. (3)

[END OF QUESTION PAPER]