

**Trial Examination
2012**

CHEMISTRY – Paper 1

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Answer all the questions in **Section A** and **Section B**.

Section A

1. The compound NCl_3 is formed from ^{14}N , ^{35}Cl and ^{37}Cl isotopes. The relative abundance of ^{35}Cl to ^{37}Cl is 3:1. Which statement about the mass spectrum of NCl_3 is true?

- A The base peak corresponds to N^+ ion
B The m/e value for the last peak is 123.
C The number of peaks for NCl_3^+ is 4.
D The relative abundance of $\text{N}^{35}\text{Cl}_3^+$ ion to $\text{N}^{37}\text{Cl}_3^+$ is 3:1.

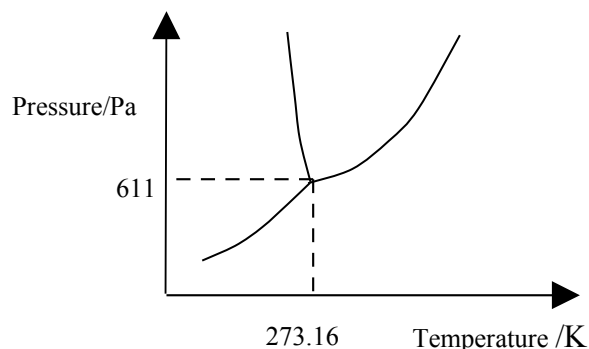
2. Two liquids, P and Q of the same volume are allowed to evaporate. It is found that P evaporates first before Q does. Which statement explains this observation?

- A The vapour pressure of P is lower than that of Q.
B The intermolecular force of P is weaker than that of Q.
C The density of P is higher than that of Q.
D Q is more viscous than P.

3. Ammonia is a non-ideal gas. What is the reason?

- A The volume occupied by the molecules cannot be ignored.
B The intermolecular forces are strong.
C The gas is easily compressed at high pressure.
D The molecules are small.

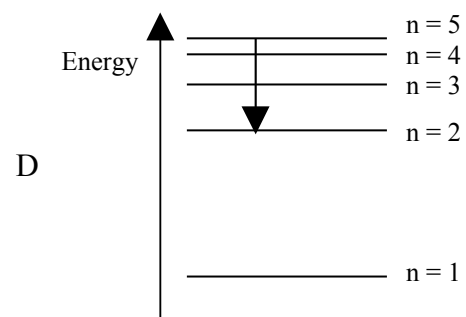
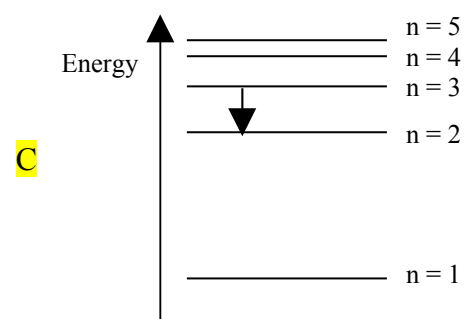
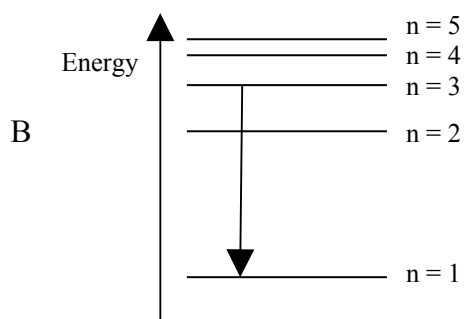
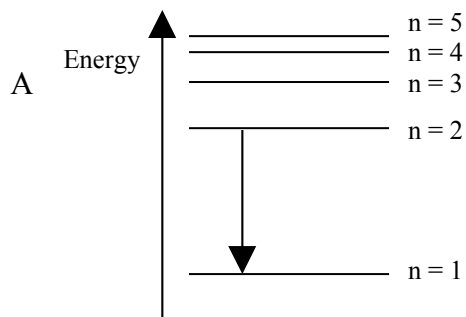
4. A phase diagram of water is shown below.



What can be deduced from the phase diagram?

- A** An increase in pressure will decrease the freezing point of water.
B An increase in pressure will decrease the boiling point of water
C Ice sublimates at a pressure higher than 611 Pa.
D Water exists as a liquid at a pressure of 611 Pa and a temperature of 298 K.
5. Fullerene is an allotrope of carbon. What is the coordination number of the carbon atom in fullerene?
- A 2
B **3**
C 4
D 5

6. Transition of electrons between energy levels in an atom will cause an absorption or emission of light. Which energy level diagram shows the transmission of electrons that emits light with the longest wavelength?



7. A compound P with a high melting point dissolves in water, and conducts electricity in molten state. Compound P most probably could be

A potassium carbonate
 B magnesium oxide
 C aluminium chloride
 D strontium sulphate

8. Polyatomic molecules and ions have varied geometries. Which species and geometry correspond correctly?

Species	Geometry
A NH_2^-	Linear
B H_3O^+	Trigonal planar
C SiCl_4	Square planar
D ICl_3	T-shaped

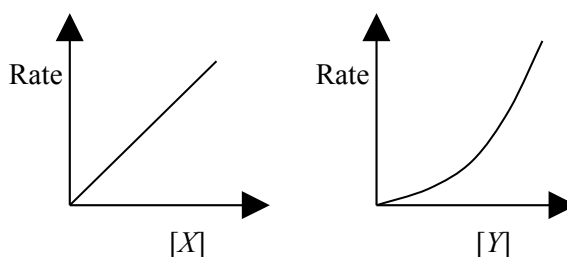
9. Coordinate bonds do **not** exist in

A NH_4^+
B BeCl_2
 C PH_4^+
 D $[\text{Cu}(\text{NH}_3)]^{2+}$

10. The graphs of initial rate verses concentration of reactants for the reaction



are shown below.



What is the order of the reaction with respect to X and Y?

	X	Y
A	0	1
B	1	0
C	1	2
D	2	1

11. Which of the following electronic configurations represents an element that forms a simple ion with a charge of -3?

A $1s^2 2s^2 2p^6 3s^2 3p^3$
 B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$
 C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$
 D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$

12. $2W + X + Y \rightarrow Z$

The rate equation for the reaction is
 $\text{rate} = k [X]^2 [W]$.

Which condition will **not** increase the rate of the forward reaction?

A Increasing the temperature
 B Adding a suitable catalyst
C Increasing the concentration of Y
 D Increasing the concentration of W

13. In which reaction the value of K_c equals the value of K_p ?

A $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
 B $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$
 C $H_2O(g) + C(s) \rightleftharpoons H_2(g) + CO(g)$
D $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

14. An aqueous solution of a monobasic acid has pH 3.5. 25.00 cm^3 of the aqueous acid is completely neutralized by 27.50 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution. The value of the dissociation constant of the acid is

A $3.16 \times 10^{-4} \text{ mol dm}^{-3}$
 B $3.48 \times 10^{-5} \text{ mol dm}^{-3}$
C $9.08 \times 10^{-7} \text{ mol dm}^{-3}$
 D $9.99 \times 10^{-8} \text{ mol dm}^{-3}$

15. Which of the following is **not** required in the calculation of the lattice energy of calcium oxide using the Born-Haber cycle?

A Enthalpy of hydration
 B Enthalpy of ionisation
 C Enthalpy of atomisation
 D Electron affinity

16. A quantity of 28 g of nitrogen is mixed with 32 g of oxygen at 298 K and 101 kPa. Which statement best describes the mixture of gases formed?

[Relative atomic mass: N = 14; O = 16]

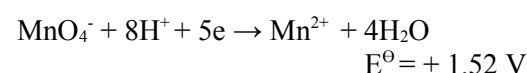
A More oxygen than nitrogen molecules are found in the mixture.
 B The average velocities of the nitrogen and the oxygen molecules are the same.
C The average kinetic energies of the nitrogen and the oxygen molecules are the same.
 D There is no transfer of kinetic energy when nitrogen and oxygen molecules collide.

17. Hydrogen and iodine vapour are mixed at 425°C . What are the concentrations, in mol dm^{-3} , of hydrogen, iodine and hydrogen iodide at equilibrium?

[Equilibrium constant, K_c at 425°C is 57.7]

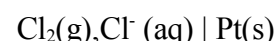
	Hydrogen	Iodine	Hydrogen Iodide
A	0.030	0.020	0.186
B	0.120	0.110	0.761
C	0.646	0.150	0.041
D	0.893	0.646	0.010

18. The standard reduction electrode potential of two half-reactions in a cell are given below



Which of the following statements is **not** correct?

A The e.m.f. of the cell is + 0.16 V.
 B Electrons flow from the chlorine half-cell to the manganate(VII) half-cell.
C The cell diagram is written as



D The standard reduction electrode potential for the manganate(VII) half-cell is affected by the pH of the solution.

19. A current of 8 A is passed for 100 min through molten aluminium oxide using carbon electrodes.

What will be the approximate volume of gas liberated, measured at s.t.p.?

[Molar volume of gas at s.t.p. = $22.4 \text{ dm}^3 \text{ mol}^{-1}$; Faraday constant = $9.65 \times 10^4 \text{ C mol}^{-1}$]

- A** 2.8 dm^3
 B 5.6 dm^3
 C 8.4 dm^3
 D 11.2 dm^3

20. Ionisation energy of Na = $+496 \text{ kJ mol}^{-1}$

Electron affinity Cl = -349 kJ mol^{-1}

Enthalpy of atomisation of Na = $+108 \text{ kJ mol}^{-1}$

Enthalpy of atomisation Cl = $+121 \text{ kJ mol}^{-1}$

Enthalpy of formation NaCl = -411 kJ mol^{-1}

Using the data above, calculate ΔH^θ for the reaction

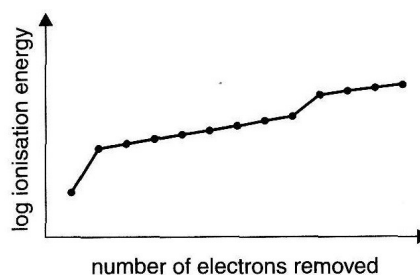


- A -35 kJ mol^{-1}
 B $+376 \text{ kJ mol}^{-1}$
 C $+663 \text{ kJ mol}^{-1}$
D $+787 \text{ kJ mol}^{-1}$

21. On going down Group 2 (from Mg to Ba), the solubility of metal sulphates decreases. Which of the following statements explains this property?

- A The electronegativity of the metals increases.
 B The ionisation energy of the metals decreases.
C The hydration energy of the cations decreases.
 D The lattice energy of the metal sulphates increases.

22. The figure below shows the log ionisation energy for the electrons in the outer shells of an atom X.



The atom X is most likely to be

- A argon
 B aluminium
C potassium
 D calcium

23. Which of the following is not a characteristic of aluminium chloride?

- A It is a covalent compound which sublimates at 180°C .
 B It undergoes hydrolysis in water to produce an acidic solution.
C It is used as a catalyst in the nucleophilic substitution involving the benzene ring.
 D Al_2Cl_6 is formed using coordinate bonds.

24. The decrease in the enthalpy of hydration of the elements on descending Group 2 is due to

- A** increase in ionic size of the cations
 B the decrease in ionisation energy
 C increase in hydrophobic effect
 D decreasing electron affinity

25. Which of the following statements is **not** true about fullerene?

- A It is an allotrope of carbon.
 B Complete combustion of fullerene produces carbon dioxide and water.
 C Each carbon atom is bonded to three other carbon atoms.
D Each carbon atom uses sp^3 hybridised orbital to form C-C bonds.

26. The substances below are all present in the exhaust fumes of a car engine. Which one of these substances could contribute to 'acid rain'?

A NO
 B CO
 C C₂H₄
 D PbO

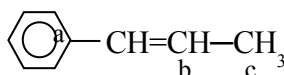
27. Which of the following products is **not** obtained commercially by the electrolysis of concentrated brine?

A chlorine
 B sodium hydroxide
 C hydrogen
D oxygen

28. Which of the following arrangement is in increasing acid strength?

A CH₃COOH, C₆H₅COOH, CH₃CH₂COOH
B CH₃CH₂COOH, CH₃COOH, C₆H₅COOH
 C CH₃CH₂COOH, C₆H₅COOH, CH₃COOH
 D CH₃COOH, CH₃CH₂COOH, C₆H₅COOH

29. The organic compound with three of its carbon atoms labelled a, b, and c is shown below.



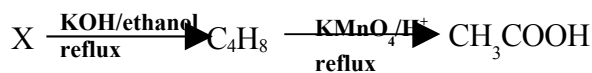
What are the types of hybrid orbitals formed by each of the carbon atoms a, b, and c?

	a	b	c
A	sp	sp ²	sp ²
B	sp ³	sp	sp ²
C	sp ²	sp ²	sp ³
D	sp ³	sp ²	sp ²

30. Which of the following steps represents the chain propagation step in the free radical reaction?

A CH₂Cl• + CH₂Cl• → CH₂ClCH₂Cl
 B Cl₂ → Cl• + Cl•
C Cl• + CH₃Cl → CH₂Cl• + HCl
 D CH₃Cl → CH₃• + Cl•

31. A reaction sequence is shown below:



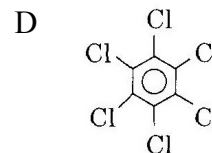
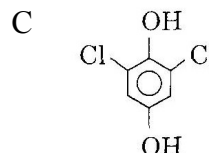
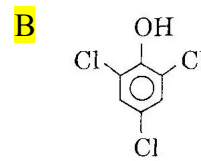
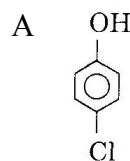
What is the starting material, X?

A 1-bromobutane
B 2-bromobutane
 C 1-bromo-2-methylpropane
 D 1,2-dibromobutane

32. Chlorofluorocarbons have been widely used as aerosol propellants and refrigerants, but are known to destroy ozone in the stratosphere. Which substance will not destroy ozone and can be used safely as a replacement for chlorofluorocarbons?

A CH₂F₂
 B CCl₃Br₃
 C CHClFCHClF
 D CH₃CHCl₂

33. Which of the following is formed when chlorine water is added to phenol?



34. The reaction between benzaldehyde and 2,4-dinitrophenylhydrazine is known as

A hydrolysis
B condensation
 C oxidation
 D nucleophilic addition

35. A compound Y, has the following properties.

- (i) It can undergo esterification.
- (ii) It has no reaction when refluxed with acidified KMnO_4 .

Compound Y is likely to have the structural formula

- A $\text{CH}_3\text{COOCH}_3$
- B** $\text{CH}_3\text{CH}_2\text{COOH}$
- C $\text{CH}_2(\text{OH})\text{CH}_2\text{COOH}$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CHO}$

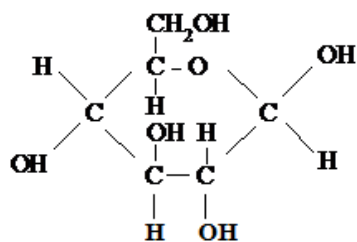
36. Which of the following organic compounds will **not** produce benzoic acid on hydrolysis?

- A $\text{C}_6\text{H}_5\text{CN}$
- B $\text{C}_6\text{H}_5\text{COCl}$
- C $\text{CH}_3\text{O}-\overset{\text{O}}{\overset{\parallel}{\text{C}}}-\text{C}_6\text{H}_5$
- D** $\text{C}_6\text{H}_5\text{CH}_2-\overset{\text{O}}{\overset{\parallel}{\text{C}}}-\text{O}-\text{C}_6\text{H}_5$
 $\text{OoOooo}-\text{C}-\text{C}_6\text{H}_5$

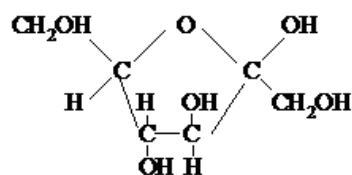
37. Which pair of compounds can be distinguished by means of aqueous diamminesilver(I) ions?

- A CH_3COCH_3 and $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
- B HCHO and $\text{CH}_3\text{CH}_2\text{CHO}$
- C** $\text{C}_6\text{H}_5\text{COCH}_3$ and $\text{CH}_3\text{CH}_2\text{CHO}$

D



and



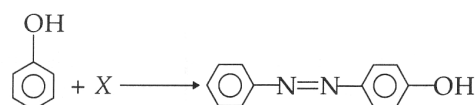
38. A type of wax has the formula



Identify the organic products formed when the wax is refluxed with hydrochloric acid.

- A** $\text{CH}_3(\text{CH}_2)_{26}\text{COOH}$ and $\text{CH}_3(\text{CH}_2)_{31}\text{OH}$
- B $\text{CH}_3(\text{CH}_2)_{26}\text{OH}$ and $\text{CH}_3(\text{CH}_2)_{31}\text{COOH}$
- C $\text{CH}_3(\text{CH}_2)_{26}\text{COOH}$ and $\text{CH}_3(\text{CH}_2)_{31}\text{COOH}$
- D $\text{CH}_3(\text{CH}_2)_{27}\text{OH}$ and $\text{CH}_3(\text{CH}_2)_{31}\text{OH}$

39. The reaction between phenol and a compound X produces an orange dye.



Which of the following reagents can be used to produce X?

- A NO_2 and HCl
- B** NO_2 and NaNO_2 and HCl
- C CN and HNO_3
- D** NH_2 and NaNO_2 and HCl

40. Some aminoethanoic acid is dissolved in a buffer solution of $\text{pH} = 9.0$. Which one of the following gives the structures of the two main forms of aminoethanoic acid at this pH ?

- A $\text{H}_3\text{N}^+\text{CH}_2\text{COOH}$ and $\text{H}_2\text{NCH}_2\text{COOH}$
- B $\text{H}_3\text{N}^+\text{CH}_2\text{COOH}$ and $\text{H}_3\text{N}^+\text{CH}_2\text{COO}^-$
- C $\text{H}_3\text{N}^+\text{CH}_2\text{COO}^-$ and $\text{H}_2\text{NCH}_2\text{COO}^-$
- D $\text{H}_2\text{NCH}_2\text{COOH}$ and $\text{H}_2\text{NCH}_2\text{COO}^-$

Section B

For each of the questions in this section one or more of the three numbered statements **1** to **3** may be correct. Determine which of the statements is correct. The response **A** to **D** should be selected on the basis of the following.

A	B	C	D
Only 1 is correct	Only 1 and 2 are correct	Only 2 and 3 are correct	1, 2 and 3 are correct

41. The equation for ideal gas is as follows:

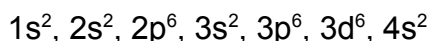
$$pV = nRT$$

Which of the following statements is true?

- One mole of any ideal gas will occupy the same volume at the same temperature and pressure.
- The density of an ideal gas at constant pressure is inversely proportional to the temperature.
- The volume of an ideal gas with a constant mass will double if the temperature is raised from 10 °C to 20 °C at constant pressure.

B

42. An element has this electronic configuration:



Which of the following about the element is true?

- It is in Group II of the Periodic Table
- It is in the fourth Period of the Periodic Table.
- It has a high melting point and boiling point.

C

43. The ionic product of water ($K_w = 1 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ at 25 °C) increases with an increase in temperature. This means

- the pH of hot water is higher than the pH of cold water
- the electrical conductivity of hot water is greater than that of cold water
- the dissociation of water molecules absorbs heat

C

44. The relationship between rate constant and temperature is given by the Arrhenius equation below:

$$k = Ae^{\frac{-E}{RT}}$$

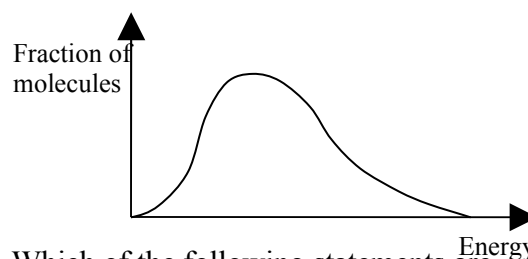
[k = rate constant, A = Arrhenius constant, E = activation energy, R = gas constant, T = temperature]

Which of the following is/are **not** correct?

- k increases when the activation energy increases.
- k is independent of the activation energy.
- k increases when temperature increases.

B

45. The Boltzmann distribution curve at a given temperature is shown below.



Which of the following statements are correct when the temperature increases?

- The highest point of the curve is displaced to the right.
- More molecules have higher energy.
- The total number of molecules remain the same.

D

46. Which of the following reagents react with both ethanal and benzaldehyde?

- Alkaline iodine solution
- 2,4-dinitrophenylhydrazine
- Tollen's reagent

C

47. In the reaction between a ketone and HCN catalysed by NaCN, which of the following statements about the reaction mechanism is/are true?

- 1 A new carbon-carbon bond is formed.
- 2 In the intermediate, the oxygen atom carries a negative charge.
- 3 The last stage involves the formation of a hydrogen-oxygen bond

D

48. Amino acid is highly soluble in water compared to other organic compounds.

This is because

- 1 the compound is amphoteric in nature
- 2 the molecule can form hydrogen bonds with water molecules
- 3 the molecule is polar

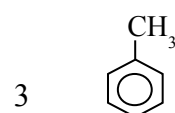
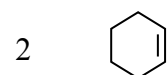
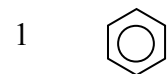
C

49. Ethanoyl chloride can be used to synthesise

- 1 $\text{CH}_3\text{COOCH}_3$
- 2 $\text{CH}_3\text{COOC}_6\text{H}_4\text{COOH}$
- 3 $\text{C}_6\text{H}_5\text{NHCH}_3$

B

50. Which of the following will decolourise acidified potassium manganate(VII)?



C

**Trial Examination
2012**

CHEMISTRY – Paper 2

Prepared by:

Checked by:

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***Circle the questions you have
answered in this table.***

Instructions to candidates:

*Answer **all** the questions in Section A. Write your answers in the spaces provided.*

*Answer any **four** questions from Section B. For this section, write your answers on the answer sheets provided. Begin each answer on a fresh sheet of paper and arrange your answers in numerical order. Tie your answer sheets to this booklet.*

All working should be shown. For numerical answers, units should be quoted wherever they are appropriate

Answers may be written in either English or Bahasa Malaysia.

A Data Booklet is provided.

For examiner's use	
1	
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9	
10	
Total	

Section A [40 marks]*Answer **all** the questions in this section.*

1. The proton number of chromium is 24.

(a) Write the valence electronic configuration of

(i) The chromium atom, [1 mark]

.....

(i) The chromium(III) ion. [1 mark]

.....

(b) (i) Sketch the relative energy level of the 3d and 4s orbitals in the chromium atom **before** electrons are filled. [2 marks]

(i) Sketch the relative energy level of the 3d and 4s orbitals in the chromium atom **after** electrons are filled. [2 mark]

(iii) State Hund's rule. [1 mark]

.....

(iv) Draw the energy diagram to show the filling of electrons in the valence orbitals of chromium based on Hund's rule. [1 mark]

(c) Draw labelled diagrams to illustrate the shapes of all the orbitals in the chromium atom with principle quantum number $n = 2$. [3 marks]

- 2 (a) The tetrachlorides of Group 14 elements, i.e. CCl_4 , SiCl_4 , GeCl_4 , SnCl_4 and PbCl_4 are liquids at room temperature. All the tetrachlorides, with the exception of CCl_4 , are hydrolysed in aqueous solution to form acidic solutions.

(i) State the molecular shape of all the Group 14 tetrachlorides. [1 mark]

(ii) Among the tetrachlorides of the Group 14 elements, state the tetrachloride that has the highest boiling point. [1 mark]

(iii) Write a balanced equation for the hydrolysis of SiCl_4 . [1 mark]

(iv) Explain why CCl_4 does not undergo hydrolysis. [1 mark]

- (b) The standard electrode potentials, at 298 K, for some half-cells are given below.

Half-cell	E°/V
$\text{Ge}^{4+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ge}^{2+}(\text{aq})$	-1.60
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}(\text{aq})$	+0.15
$\text{Pb}^{4+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+}(\text{aq})$	+1.80

(i) Arrange the Ge^{4+} ion, Sn^{4+} ion and Pb^{4+} ion in the order of decreasing stability in aqueous solutions. [1 mark]

(ii) Which ion has the most powerful reducing property? [1 mark]

(iii) Which is more stable in aqueous solutions, Pb^{2+} or Pb^{4+} ? Explain your answer. [2 marks]

(c)

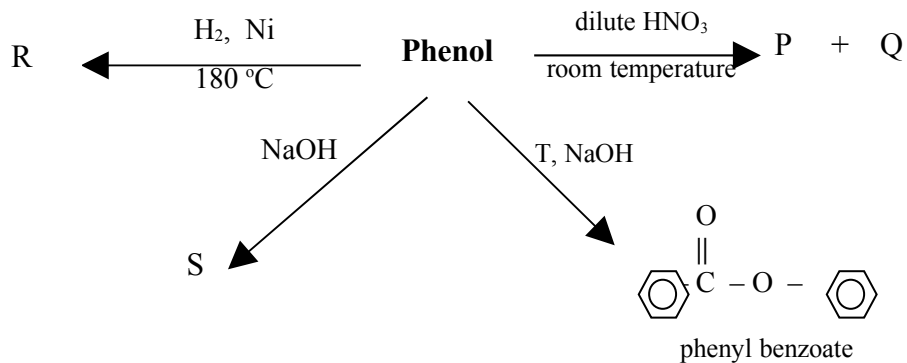
Element	Carbon	Silicon	Germanium
Bond energy (kJmol^{-1})	350	222	188

Carbon has the ability to catenate to form stable long chain and ring compounds.

(i) What is the condition for catenation to occur? [1 mark]

(ii) Explain why carbon has the ability to catenate, but not the other elements in Group 14. [1 mark]

3. The reaction scheme below shows the reactions involving phenol.



(a) (i) Draw the structural formula of P and Q. [2 marks]

(ii) Suggest how P and Q may be separated. [1 mark]

(b) Phenol reacts with hydrogen gas in the presence of nickel to form R.

(i) Identify compound R [1 mark]

(ii) Write an equation for the reaction between phenol and hydrogen. [1 mark]

(iii) How can you determine that all the phenol has been converted to R? [1 mark]

(iv) Explain why phenol is more acidic than R [1 mark]

(c) (i) S is formed from the reaction of phenol and sodium hydroxide. What is S? [1 mark]

(ii) Write an equation for the reaction. [1 mark]

- (d) A white precipitate, phenyl benzoate is formed when phenol reacts with T in the presence of sodium hydroxide.

Write the structural formula of T.

[1 mark]

4. (a) Starting with 1-bromopropane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$, show the reaction schemes to synthesise the following carboxylic acids.

(i) $\text{CH}_3\text{CH}_2\text{COOH}$

[2 marks]

(ii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$

[2 marks]

- (b) Write equations for the reactions between benzoyl chloride, $\text{C}_6\text{H}_5\text{COCl}$, with the following compounds and name the organic products according to the IUPAC nomenclature.

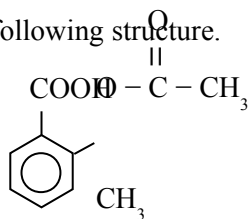
(i) H_2O

[2 marks]

(ii) CH_3NH_2

[2 marks]

- (c) Aspirin has the following structure.



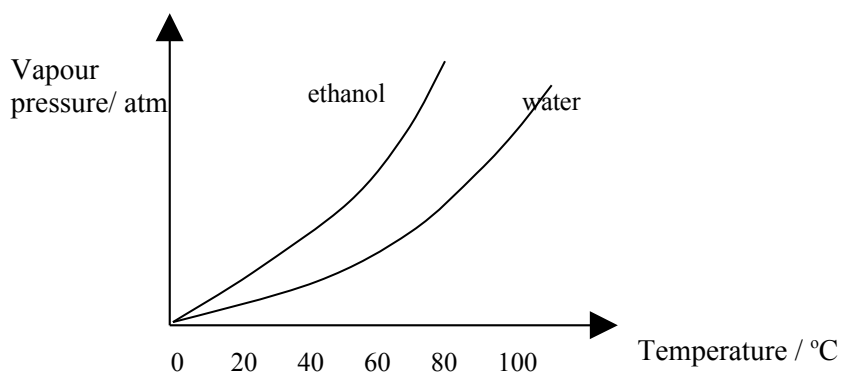
Give the products formed when aspirin is heated with aqueous potassium hydroxide. [2 marks]

Section B [60 marks]

Answer any **four** questions in this section.

5. Water and ethanol are two separate solvents normally used in the laboratory.

(a) A graph of vapour pressure versus temperature of water and ethanol is shown below.

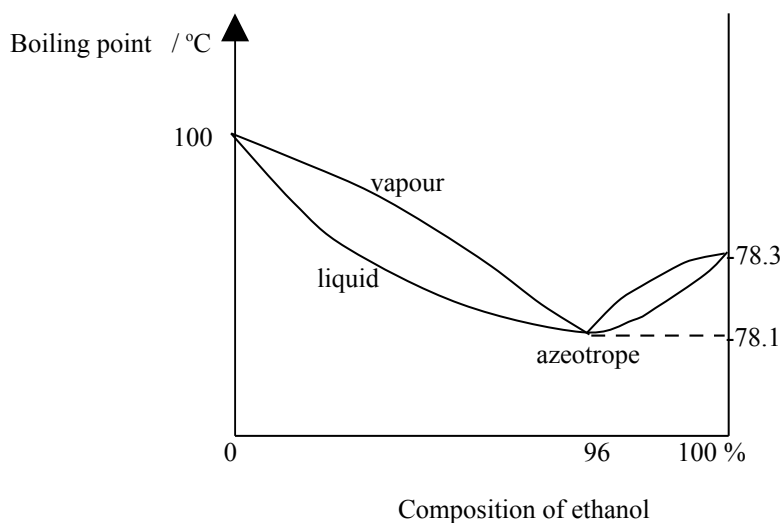


(i) Define the term *vapour pressure*. [2 marks]

(ii) Using the *kinetic theory*, explain the change in vapour pressure with the change in the temperature of water. [4 marks]

(iii) Explain the difference between the vapour pressure of water and that of ethanol at 60 °C. [3 marks]

(b) The boiling point-composition phase diagram for the solution of ethanol in water is shown below.



(i) Discuss the type of deviation from Raoult's law for the above solution. [3 marks]

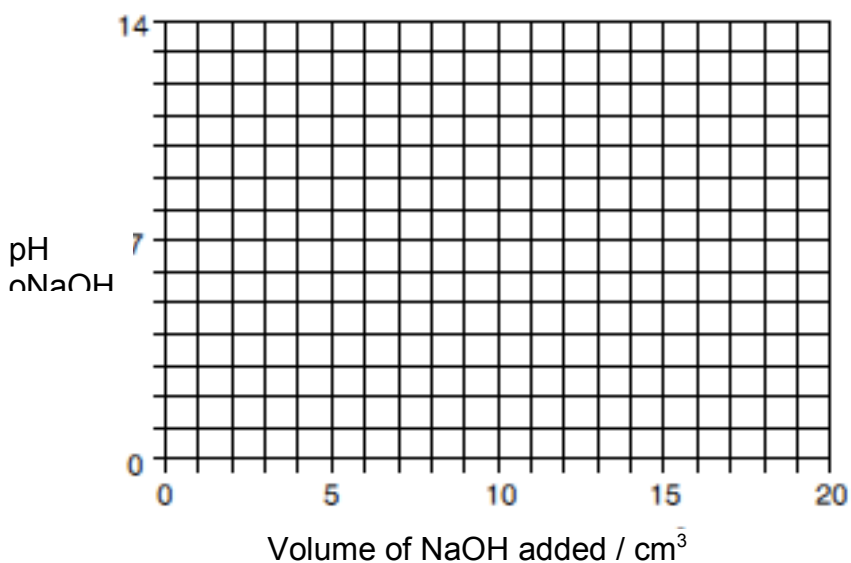
- (ii) The alcoholic solution formed from the fermentation of carbohydrates contains 12% to 15% of ethanol. Explain why pure ethanol cannot be obtained from the alcoholic solution by fractional distillation. In your answer, show the paths of fractional distillation on the phase diagram. [4 marks]

- 6 (a) Explain what is meant by the Bronsted-Lowry theory of acids and bases. [2 marks]

- (b) The K_a values for some organic acids are listed below.

acid	$K_a / \text{mol dm}^{-3}$
CH_3COOH	1.7×10^{-5}
ClCH_2COOH	1.3×10^{-3}
Cl_2CHCOOH	5.0×10^{-2}

- (i) Explain the trend in K_a values in terms of the structures of these acids. [3 marks]
- (ii) Calculate the pH of a 0.10 mol dm^{-3} solution of ClCH_2COOH . [2 marks]
- (iii) Use the following axes to sketch the titration curve you would obtain when 20 cm^3 of 0.10 mol dm^{-3} NaOH is added gradually to 10 cm^3 of 0.10 mol dm^{-3} ClCH_2COOH .



[3 marks]

- (iv) Suggest a suitable indicator for this titration. [1 mark]

- (c) (i) Write suitable equations to show how a mixture of ethanoic acid, CH_3COOH , and sodium ethanoate acts as a buffer solution to control the pH when either an acid or an alkali is added. [2 marks]

- (ii) Calculate the pH of a buffer solution containing 0.10 mol dm^{-3} ethanoic acid and 0.20 mol dm^{-3} sodium ethanoate. [2 marks]

7. (a) The equation for the decomposition of N_2O_5 is given below :



The above reaction is of first order and the half-life is 2.7×10^3 s.

- (i) Write the rate equation for the above reaction. [1 mark]
- (ii) Calculate the rate constant. [2 mark]
- (iii) Calculate the rate of reaction when the concentration of N_2O_5 is $3.1 \times 10^{-2} \text{ mol dm}^{-3}$. [2 marks]
- (iv) If the reaction involves the formation of free radical. Suggest a mechanism for the decomposition. Explain your answer. [2 marks]

- (b) Data for the decomposition of $\text{HI}_{(\text{g})}$ to $\text{H}_{2(\text{g})}$ is given in the table below.

Enthalpy of decomposition / kJ mol^{-1}	Activation energy / kJ mol^{-1}	Catalyst
53.0	164.0	Without catalyst
	59.0	Platinum powder

- (i) What is meant by activation energy? [1 mark]
- (ii) Explain the role of platinum in the above decomposition.
- (iii) Based on the above data, sketch an energy level diagram for the decomposition of $\text{HI}_{(\text{g})}$.

[7 marks]

- 8 (a) A solution of sodium chloride of concentration 2.00 mol dm^{-3} is electrolysed for 25 minutes using graphite electrodes. The resulting solution is then titrated with hydrochloric acid of concentration 0.25 mol dm^{-3} . If the volume of hydrochloric acid needed for complete titration is 15.50 cm^3 , calculate the magnitude of the current used during the electrolysis.
[Faraday constant = 9.65×10^4]

[7 marks]

- (b) the partition coefficient for a solute S between ether and water is 12.50.

- (i) By referring to solute S, ether and water, explain what is meant by partition law. [2 marks]
- (ii) Suggest the conditions at which the partition law holds true. [2 marks]
- (iii) Calculate the mass of S remaining in 25.0 cm^3 of water that originally contains 8.00 g of S after :
 - (I) a single extraction using 25 cm^3 of ether
 - (II) two extractions, using 12.50 cm^3 of ether for each extraction

[4 marks]

9. (a) (1-methylethyl)benzene or cumene is an important intermediate used in the industrial manufacture of phenol. (1-methylethyl)benzene is produced by a Friedel-Crafts reaction between benzene and a suitable alkene.

(i) Write an equation to show the formation of cumene and name the catalyst used. [2 marks]

(ii) Describe with the aid of equations how cumene is converted to phenol [4 marks]

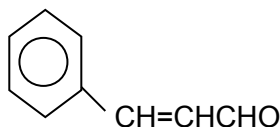
(b) Suggest explanations for the following reactions.

(i) Phenol can be nitrated by dilute nitric acid to give a mixture of monosubstituted phenol, whereas benzene is only nitrated by a mixture of concentrated nitric and concentrated sulphuric acids.

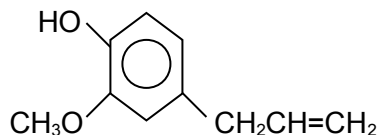
(ii) Heating 2-butanol with excess concentrated sulphuric acid produces a mixture of three isomeric alkenes.

[9 marks]

10. The structural formulas for the organic compounds Cinnamaldehyde and Eugenol are as follows:



Cinnamaldehyde



Eugenol

(a) Give a chemical test to distinguish between Cinnamaldehyde and Eugenol [3 marks]

(b) Eugenol is treated with the following reagents:

(i) bromine water

(ii) concentrated acidified potassium manganate(VII) solution.

In each case, describe what is observed and write the formulas of the products obtained.

[4 marks]

(c) (i) State the functional groups in an amino acid molecule.

(ii) Glycine or 2- aminoethanoic acid is a solid with a high melting point. It is soluble in water but is insoluble in ether. Draw the full structural formula of glycine when dissolved in water and explain the given observations.

(iii) Indicate, with a balanced equation, how a peptide bond is formed between two glycine molecules.

- (iv) Write equations for the reaction of glycine with hydrochloric acid and aqueous sodium hydroxide.




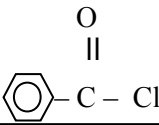

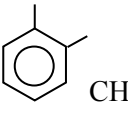

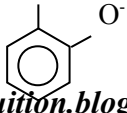
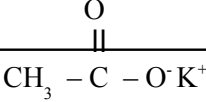
[8 marks]

SMK Seafield, Subang Jaya
Trial Examination 2012 - STPM Chemistry
Marking Scheme

Section A

1	(a) (i)	$4s^1 3d^5$ or $3d^5 4s^1$	1
	(ii)	$3d^3$	1
	(b) (i)	<div style="display: flex; align-items: center;"> <div style="margin-right: 20px;"> <p>Energy ↑</p> </div> <div> <p>Correct relative energy</p> <p>Five 3d orbitals</p> </div> </div>	1 1
	(ii)	<div style="display: flex; align-items: center;"> <div style="margin-right: 20px;"> <p>Energy ↑</p> </div> </div>	1
	(iii)	Hund's rule - When electrons are placed in a set of degenerate orbitals, /(sub-shell) / (orbitals with equal energies), the electrons must occupy them singly with parallel spins before they occupy the orbitals in pairs.	1
	(iv)	<div style="display: flex; align-items: center; justify-content: center;"> <div style="margin-right: 20px;"> <p>3d</p> </div> <div> <p>4s</p> </div> </div>	1
	(c)	<div style="display: flex; align-items: center;"> <div style="margin-right: 20px;"> <p>2s</p> </div> <div> <p>2p</p> </div> <div style="margin-left: 20px;"> <p>labelled axes</p> <p>2 s orbital</p> <p>2 p orbitals</p> </div> </div>	1 1 1
			10

2	(a) (i)	Tetrahedron	1
	(ii)	PbCl ₄	1
	(iii)	SiCl ₄ + 2H ₂ O → SiO ₂ + 4HCl	1
	(iv)	Carbon does not have d orbital to form coordinate bond with water.	1
	(b) (i)	Ge ⁴⁺ > Sn ⁴⁺ > Pb ⁴⁺	1
	(ii)	Ge ²⁺	1
	(iii)	Pb ²⁺	1
		Because the charge density is lower // Value of E ⁰ is positive // - Atomic radius increases down the group - Force of attraction between the nucleus and the valence electrons decreases - Tendency of losing 2 electrons from the p orbitals by Pb ⁴⁺ to form Pb ²⁺ increases	1
	(c) (i)	The chemical bond between the atoms must be strong	1
	(ii)	The carbon atom is small in size	1
			10

3	(a) (i)		1+ 1
	(ii)	Fractional distillation	1
	(b) (i)	cyclohexanol	1
	(ii)	C ₆ H ₅ OH + 3H ₂ → C ₆ H ₁₁ OH	1
	(iii)	Add iron(III) chloride solution,  If phenol is still present, the solution turns purple // Add aqueous bromine solution, If phenol is still present, the a white precipitate is formed	1
	(iv)	C ₆ H ₅ OH → C ₆ H ₅ O ⁻ + H ⁺ The phenoxide ion formed  Mg stabilised by delocalisation of electrons into the benzene ring anhydrous ether	1
	(c) (i)	Phenoxide ion/ sodium phenoxide	1
	(ii)	C ₆ H ₅ OH + NaOH → C ₆ H ₅ ONa + H ₂ O	1
	(d)	 <div style="display: inline-block; vertical-align: middle; margin-left: 20px;">  <p>(i) CO₂ (ii) H₂O/H⁺</p> <p>CH₃CH₂CH₂COOH</p> </div>	1
			10
4	(a) (i)	CH ₃ CH ₂ CH ₂ Br + NaOH(aq) → CH ₃ CH ₂ CH ₂ OH	1
		<div style="text-align: center;">K₂Cr₂O₇/H⁺, Δ</div> <div style="display: flex; justify-content: space-around;"> CH₃CH₂CH₂OH CH₃CH₂COOH </div>	1
	(ii)	CH ₃ CH ₂ CH ₂ BO ⁺ + NaCN → CH ₃ CH ₂ CH ₂ CN	1
		<div style="display: flex; justify-content: space-between;"> <div>  </div> <div>  </div> <div>  </div> <div>  </div> </div> <p style="text-align: center;">KOH(aq) Δ</p>	1

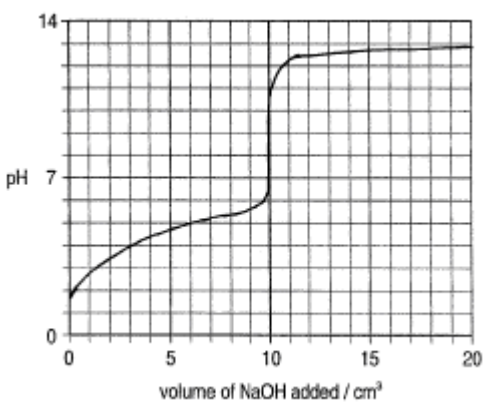
		or $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ $\text{CH}_3\text{CH}_2\text{CH}_2\text{MgBr}$	
	(b) (i)	$\text{C}_6\text{H}_5\text{COCl} + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_5\text{COOH} + \text{HCl}$ benzoic acid	1 1
	(ii)	$\text{C}_6\text{H}_5\text{COCl} + \text{CH}_3\text{NH}_2 \rightarrow \text{C}_6\text{H}_5\text{CONHCH}_3 + \text{HCl}$ N-methylbenzamide	1 1
	(c)		2
			10

Section B

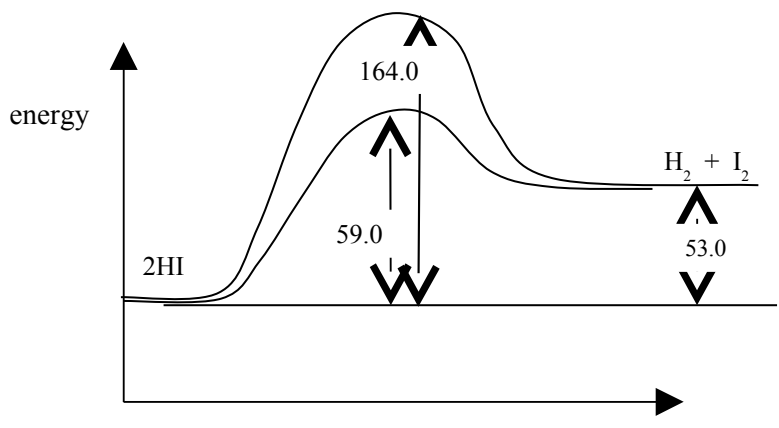
5	(a) (i)	- Vapour pressure is the pressure due to the collision on the wall of the vessel - by vapour molecules in equilibrium with is liquid	1 1 ... 2
	(ii)	- Vapour pressure is higher at higher temperature - At a higher temperature, the water molecules have more kinetic energy - The number of water molecules in the vapour phase is higher - The rate of collision with the wall of the vessel increases / Molecules collide on the wall with greater strength	1 1 1 1 ... 4

	(iii)	<ul style="list-style-type: none"> - The vapour pressure of water is lower than the vapour pressure of ethanol - At the same temperature, water molecules is less volatile compared to ethanol - because the hydrogen bond in water is stronger 	1 1 1 ... 3
	(b) (i)	<ul style="list-style-type: none"> - Positive deviation - The mixture forms an azeotrope with minimum boiling point/maximum vapour pressure - The vapour pressure of the solution is higher than the vapour pressure of ideal solution 	1 1 1 ... 3
	(ii)	<ul style="list-style-type: none"> - When heated, the solution boils at T_1 °C, and the composition of the vapour formed is C_1 % ethanol - The vapour condenses and boils at temperature T_2 °C and the vapour composition is C_2 - The process is repeated until an azeotropic mixture 96 % ethanol is distilled at 78.1 °C - <i>The paths of fractional distillation on the phase diagram</i> 	1 1 1 1 ... 4
		Total	16 (15_{max})

6	(a) (i)	<ul style="list-style-type: none"> - Acids proton/H^+ donors - Bases are proton/H^+ acceptors 	1 1 ... 2
	(b) (i)	<ul style="list-style-type: none"> - More Cl atoms produce a stronger acid //The larger the K_a, the stronger the acid - because the anion /$RCOO^-$ ion is more stable // the O-H bond is weaker - due to the electron-withdrawing (negative inductive) effect of Cl 	1 1 1 ... 3
	(ii)	$H^+ = \sqrt{(K_a C)}$ $= \sqrt{(1.3 \times 10^{-2})(0.10)}$ $= 0.0114 \text{ mol dm}^{-3}$	1 1 ... 2

		pH = 1.9	
	(iii)	 <p>- Start at pH = 1.94 and goes up > 2 pH units before steep portion</p> <p>- Steep portion at V = 10 cm³</p> <p>- Flattens at pH 12 - 13</p>	1 1 1 ... 3
	(iv)	phenolphthalein	1 ... 1
	(c) (i)	$\text{CH}_3\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$ $\text{CH}_3\text{COO}^- + \text{H}^+ \rightarrow \text{CH}_3\text{COOH}$	1 1 ... 2
	(ii)	$\text{pK}_a = -\log_{10}(1.7 \times 10^{-5})$ $= 4.77$ Or $[\text{H}^+] = 8.5 \times 10^{-6} \text{ mol dm}^{-3}$ $\text{pH} = \text{pK}_a + \log_{10}(0.2/0.1)$ $= 5.07$ (allow 5.1)	1 1 ... 2
		Total	15

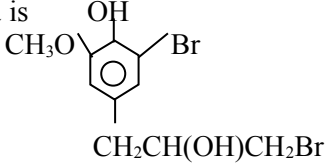
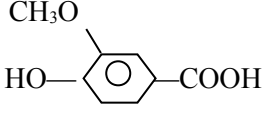
7. (a) (i)	Rate = $k[\text{N}_2\text{O}_5]$	1 ... 1
(ii)	Rate constant, $k = \frac{\ln 2}{t_{1/2}} \quad @ \quad k = \frac{0.693}{t_{1/2}}$ $k = \frac{0.693}{2.7 \times 10^3} \text{ s}^{-1}$ $= 2.6 \times 10^{-4} \text{ s}^{-1}$	1 1 ... 2
(iii)	Rate = $k [\text{N}_2\text{O}_5]$ $= (2.6 \times 10^{-4}) \times (3.1 \times 10^{-2})$ $= 8.1 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}$	1 1 ... 2
(iv)	Decomposition	

	$\text{N}_2\text{O}_5 \rightarrow 2\text{NO}_2 + \text{O}\bullet$ (a: O only) (slow) $\text{N}_2\text{O}_5 \rightarrow \text{N}_2\text{O}_4 + \text{O}\bullet$ $\text{O}\bullet + \text{O}\bullet \rightarrow \text{O}_2$ (fast)	1 1 ... 2
(b) (i)	Activation energy is the minimum energy required by a reactant to form the activated complex	1 ... 1
(ii)	<ul style="list-style-type: none"> - Platinum functions as a heterogeneous catalyst - It provides a bigger surface area - and lower activation energy - to increase the rate of reaction 	1 1 1 1 ... 4
(iii)	 <p>energy</p> <p>164.0</p> <p>59.0</p> <p>2HI</p> <p>H₂ + I₂</p> <p>53.0</p> <p>Progress of reaction</p> <ul style="list-style-type: none"> - Labelled axes (no need units) - Correct curves - Energy values marked correctly 	1 1 1 ... 3
Total		15

8. (a)	- During the electrolysis of aqueous sodium chloride, hydrogen is liberated at the cathode	1
	- While chlorine is liberated at the anode	1
	- At the cathode, $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$ Hence for every mole of electron that passes through the electrolyte, one mole of NaOH will be produced.	1
	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ No of moles of HCl used in titration = $(0.25 \times 15.50)/1000 = 3.88 \times 10^{-3} \text{ mol}$	1
	No of moles of NaOH produced = $3.88 \times 10^{-3} \text{ mol}$	1
	Quantity of charge required , $Q = 3.88 \times 10^{-3} \text{ mol} \times 96500 \text{ C} = 374.4 \text{ C}$	1
	Using $Q = It$, $374.4 = I \times 25 \times 60$	

	I = 0.25 A/	1 ... 7
(b) (i)	<p>The partition law states that a solute, s distributes itself between the two immiscible solvents, ether and water in such a way that the ration of the concentrations in the two solvent is constant.</p> $\frac{\text{Concentration of S in ether}}{\text{Concentration of S in water}} = 12.50$	1
(ii)	The partition law only holds when the temperature is constant and the molecular condition in both solvents.	1
(iii)	<p>(I) single extraction Let a be the amount of S left in the aqueous layer, $\frac{8.00 - a}{a} = 12.50$ $a = 0.59 \text{ g}$</p> <p>(II) 1st portion in 2 extractions: Let b be the amount of S left in the aqueous layer, $\frac{(8.00 - b)/12.50}{b/25.0} = 12.50$ $b = 1.10 \text{ g}$</p> <p>2nd portion in 2 extractions: Let c be the amount of S left in the aqueous layer, Amount in ether layer = (1.10 - c) g $\frac{(1.10 - c)/12.50}{c/25.0} = 12.50$ $c = 0.15 \text{ g}$</p>	1
	Total	15
9(a)(i)	$\text{C}_6\text{H}_6 + \text{CH}_2=\text{CHCH}_3 \rightarrow \text{C}_6\text{H}_5\text{CH}(\text{CH}_3)_2$ <p>Catalyst : phosphoric acid / H₃PO₄/AlCl₃</p>	1
(ii)	<p>Oxidation / reaction with oxygen</p> $\text{CH}_3-\underset{\text{C}_6\text{H}_5}{\text{CH}}-\text{CH}_3 + \text{O}_2 \rightarrow \text{CH}_3-\overset{\text{CH}_3}{\underset{\text{C}_6\text{H}_5}{\text{C}}}-\text{O}-\text{O}-\text{H}$ <p>Decomposition of hydroperoxide with dilute sulphuric acid</p> $\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{C}_6\text{H}_5}{\text{C}}}-\text{O}-\text{O}-\text{H} \rightarrow \text{C}_6\text{H}_5-\text{OH} + \text{CH}_3\text{COCH}_3$	1
		1

			4
(b)(i)	-OH in phenol is a ring activating group ./ Lone pair electrons on oxygen atom in -OH group can be delocalized into the benzene ring / donated to the benzene ring	1	
	Phenol more easily attacked by an electrophile (or NO ₂ ⁺) compare to benzene	1	
	Equation to form nitrobenzene Equation to form 2-nitrophenol and 4-nitrophenol	1 1	4
(ii)	Elimination reaction / dehydration	1	
	To form but-1-ene (1-butene) and 2- butene	1	
	Any 1 equation to form 2-butene / 1-butene	1	
	2-butene exists as pair of cis-trans isomers / shows geometrical isomers	1	
	[Draw structure of the cis and trans isomers and labelled them	1	5
			15

10 (a)	Describe test using either one of the following reagents: Tollens reagent / Fehlings solution / iron(III) chloride (cannot use Br ₂ (aq) or KMnO ₄) Observation: Equation:	1 1 1	 3
(b) (i)	Observation: brown colour of Br ₂ decolourised / and white ppt Formula is 	1 1	
(ii)	Observation: purple colour of MnO ₄ ⁻ is decolourised / and bubbles of CO ₂ observed Formula 	1 1	4
(c) (i)	-NH ₂ or amine	1	

	-COOH or carboxyl	1	2
(ii)	<ul style="list-style-type: none"> - Glycine is a zwitterions, $\text{H}_3\text{N}^+\text{CH}_2\text{COO}^-$ - There are strong forces of attraction between the dipolar ions /zwitterions Therefore, the melting point is high - Its ability to form hydrogen bonds with water molecules explains its ability to dissolve in water. 	1 1 1	3
(iii)	$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{OH} \end{array} + \begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{OH} \end{array} \longrightarrow \begin{array}{c} \text{O} \quad \text{O} \\ \parallel \quad \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{NHCH}_2\text{C}-\text{OH} \end{array} + \text{H}_2\text{O}$	1	1
(iv)	$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{OH} \end{array} + \text{HCl} \longrightarrow \text{Cl}^- \begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{N}^+\text{CH}_2\text{C}-\text{OH} \end{array}$ $\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{OH} \end{array} + \text{NaOH} \longrightarrow \begin{array}{c} \text{O} \\ \parallel \\ \text{H}_2\text{NCH}_2\text{C}-\text{O}^- \text{Na}^+ \end{array} + \text{H}_2\text{O}$	1 1	2
	Total		15