

# Basic Calculations

## Question Paper 2

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Basic Calculations-Physical Chemistry
Booklet	Question Paper 2

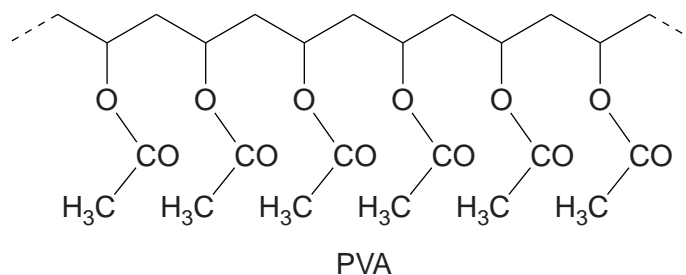
**Time Allowed:** 44 minutes

**Score:** /37

**Percentage:** /100

**Grade Boundaries:**

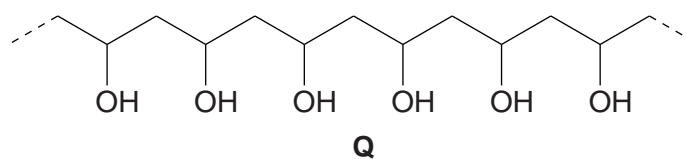
1. (a) Polyvinyl acetate (PVA) is produced on a large scale for use in glues.



- (i) Circle one repeat unit of the polymer. [1]
- (ii) Draw the structure of the monomer used to make PVA.

[1]

- (iii) Complete hydrolysis of PVA results in a polymer **Q** and a second product, **R**.



Identify **R**.

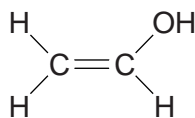
[1]

- (iv) Polymer **Q** is unusual in that it dissolves in water. Suggest why it dissolves in water.

.....

..... [1]

(v) A logical monomer to make **Q** is shown.



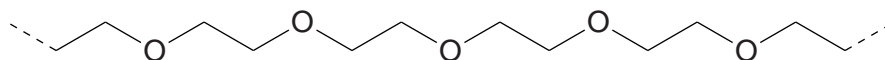
In fact this molecule is not stable. Two isomers of this molecule, **S** and **T**, can be isolated. Draw the structures of **S** and **T**.

structure of **S**

structure of **T**

[2]

(vi) One of the isomers, **S** or **T**, is the monomer for the polymer PEG.



PEG

State the functional group level of the carbon atoms in PEG and explain how this identifies which of the isomers, **S** or **T**, is the monomer for PEG.

functional group level .....

explanation .....

.....

..... [2]

- (b) (i) The complete hydrolysis of dimethyldichlorosilane,  $(\text{H}_3\text{C})_2\text{SiCl}_2$  gives two products, **V**, which contains silicon, and **W**, which does not. The Si–C bond is stable towards hydrolysis. **V** has a molar mass of  $92\text{ g mol}^{-1}$ .

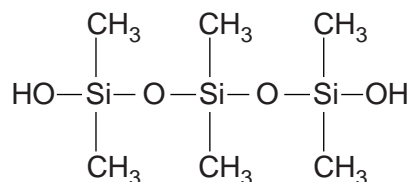
Draw the structure of **V** and give the formula of **W**.

structure of **V**

formula of **W** .....

[2]

- (ii) Three molecules of **V** can combine to form the molecule shown.



Five molecules of **V** can combine to form a molecule with a relative molecular mass of 370, where all the silicon atoms are in equivalent environments.

Suggest the structure of this molecule.

[1]

[Total: 11]

2. Grignard reagents are formed readily by iodoalkanes. This question concerns the conversion of a ketone, pentan-2-one, to a tertiary alcohol using a Grignard reagent.

Table 5.1 summarises the volatilities and hazards of the reagents and the organic product.

**Table 5.1**

substance	volatility	hazard
iodoethane	moderate	flammable; toxic; respiratory irritant
ethoxyethane	high	flammable; harmful
magnesium turnings	non-volatile	flammable
pentan-2-one	low	flammable; harmful
product alcohol	very low	flammable; irritant

- (a) (i) What are the **two** most important safety measures to guard against the hazards of these materials? You can assume that the experimenters are wearing gloves, eye protection and lab coats.

.....  
 .....  
 ..... [2]

- (ii) The day before the experiment anhydrous calcium chloride is added to the iodoethane, sodium wire is added to the ethoxyethane and the glassware is left in an oven.

Suggest the single purpose of these three precautions.

.....  
 ..... [1]

**Step one**

1.50 g of magnesium turnings is added to a pear-shaped flask with an equimolar quantity of iodoethane and 20 cm<sup>3</sup> of ethoxyethane.

Table 5.2 gives some physical properties of the reagents and the organic product.

substance	formula	molar mass /g mol <sup>-1</sup>	density /g cm <sup>-3</sup>	solubility in water	boiling point /°C
iodoethane	C <sub>2</sub> H <sub>5</sub> I	156	1.93	slightly soluble	72
ethoxyethane	C <sub>2</sub> H <sub>5</sub> OC <sub>2</sub> H <sub>5</sub>	74	0.713	slightly soluble	35
magnesium turnings	Mg	24.3	1.74	insoluble	1110
pentan-2-one	C <sub>5</sub> H <sub>10</sub> O	86	0.814	slightly soluble	102
product alcohol			0.823	slightly soluble	143

(b) (i) Calculate the amount, in mol, of magnesium used.

amount = ..... mol [1]

(ii) Calculate the volume of iodoethane required to react with the magnesium.

volume = ..... cm<sup>3</sup> [2]

(iii) Suggest the role of the ethoxyethane.

..... [1]

### Step two

A crystal of iodine is added to the mixture from **step one** to activate the magnesium, and this mixture is refluxed.

(c) (i) Suggest why elevated temperatures and long periods of time are required for reactions such as this.

.....  
 .....  
 ..... [2]

(ii) Give the structural formula of the Grignard reagent that is the product of **step two**.

..... [1]

### Step three

The mixture from **step two** is allowed to cool and  $6.0\text{ cm}^3$  of pentan-2-one is added dropwise. The mixture is then gently heated under reflux.

- (d) (i) Draw the structure of the product of the reaction between the Grignard reagent and pentan-2-one which is present at the end of **step three**.

[1]

- (ii) Show with a calculation that the Grignard reagent is in excess. Assume that the reaction between magnesium and iodoethane in **step two** had 100% yield. Use your answer to **(b)(i)**.

[2]

### Step four

The mixture from **step three** is cooled using an ice bath, and then  $25\text{ cm}^3$  of  $4\text{ mol dm}^{-3}$  hydrochloric acid is slowly added.

- (e) (i) Draw the structure of the tertiary alcohol produced by the reaction with dilute hydrochloric acid.

[1]

- (ii) What organic by-product results from the addition of the hydrochloric acid?

..... [1]

- (iii) Suggest why the mixture is cooled before adding the hydrochloric acid.

.....  
..... [1]

**Step five**

The mixture from **step four** is added to a separating funnel. The lower aqueous layer is separated and shaken successively with two 10 cm<sup>3</sup> portions of ethoxyethane, retaining the ethoxyethane extracts and combining them with the original ethoxyethane layer.

- (f) (i) Using the data in Table 5.2, explain why the ethoxyethane forms a layer above the aqueous layer.

.....  
..... [2]

- (ii) Suggest the purpose of shaking the aqueous layer with ethoxyethane.

.....  
..... [1]

**Step six**

The combined ethoxyethane layer is washed successively with 20 cm<sup>3</sup> of

1. water,
2. saturated sodium hydrogencarbonate solution,
3. 1 mol dm<sup>-3</sup> aqueous sodium thiosulfate,
4. saturated sodium chloride solution.

- (g) The water and the three aqueous solutions used to wash the ethoxyethane layer are each intended to remove a particular impurity, either by dissolving or by chemical reaction followed by dissolving.

Suggest the impurity removed in each step.

1. water ..... [1]
2. saturated sodium hydrogencarbonate ..... [1]
3. sodium thiosulfate ..... [1]
4. saturated sodium chloride ..... [1]



**Step seven**

The ethoxyethane layer is allowed to stand over anhydrous magnesium sulfate.

**(h)** What is the purpose of the anhydrous magnesium sulfate?

..... [1]

**(i)** Using the data in Table 5.2, describe how you would obtain a pure sample of the product alcohol.

.....  
.....  
..... [2]

[Total: 26]