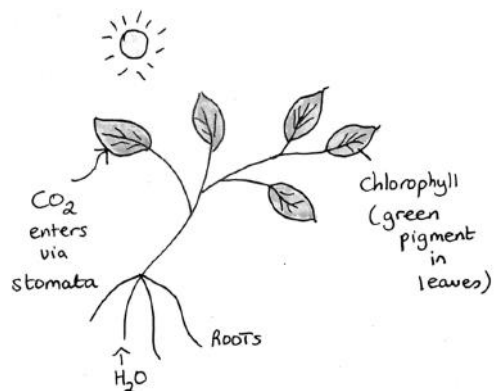



### 1.1.3 CARBOHYDRATES

- Plants have the ability to make their own food by a process called photosynthesis.

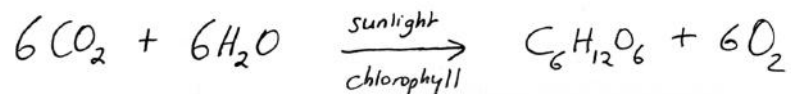


- H<sub>2</sub>O is absorbed via roots.
- CO<sub>2</sub> (from air) is absorbed via stomata in the leaves.
- Sunlight (energy) is absorbed by chlorophyll in leaves.

#### Result

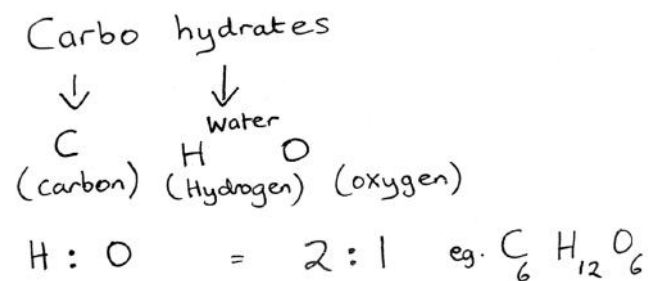
- The plant produces food (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)
- The plant food is also known as simple sugars called monosaccharides.
- They are hexose sugars. 

#### CHEMICAL EQUATION FOR PHOTOSYNTHESIS

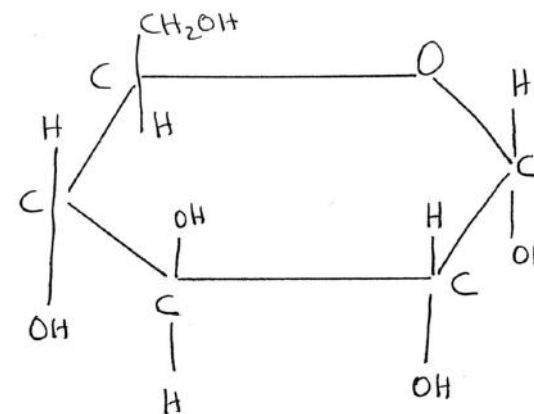


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#### ELEMENTAL COMPOSITION OF CARBOHYDRATES



- The most common monosaccharide is glucose.
- It has the following structure :


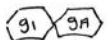






**NOTE :** The only difference between monosaccharides is their molecular arrangement (ie) : the position of Carbon, Hydrogen and Oxygen differs with each hexose sugar.

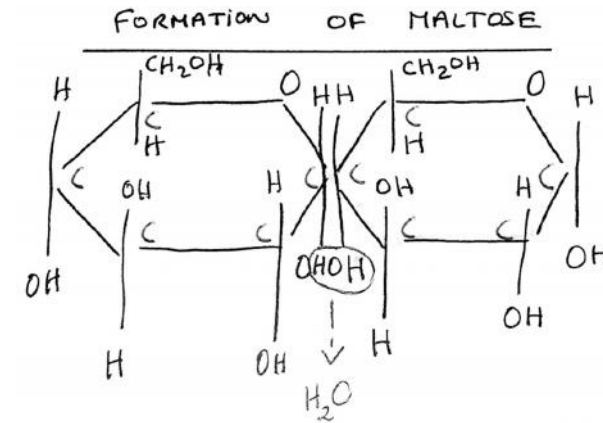
- Monosaccharides are also known as simple sugars (they cannot be broken down any further & they are absorbed easily by the villi in the small intestine)

## DISACCHARIDES

- In some plants the products of photosynthesis (ie : monosaccharides) are arranged in pairs.
- Two monosaccharides link together.
- As the chemical link is formed, one molecule of is eliminated in a condensation reaction.
  - H from one monosaccharide and OH (hydroxyl group) from the other monosaccharide.
- The chemical formula for disaccharides  $\rightarrow C_{12}H_{22}O_{11}$ 
  - NOTE** – H:O 2:1
  - $C_6H_{12}O_6 + C_6H_{12}O_6 - H_2O$ ,
  - $C_{12}H_{24}O_{12} - H_2O$ ,
  - $C_{12}H_{22}O_{11}$

EXAMPLE OF Disaccharide	FORMATION	SOURCE
SUCROSE		Table sugar
LACTOSE		Milk
MALTOSE		germinating barley

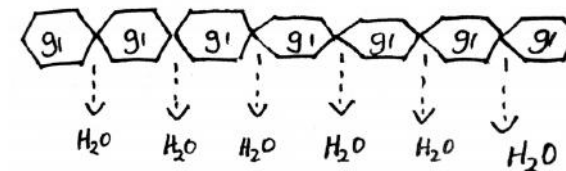
 = glucose  
 = galactose  
 = fructose



- Two glucose units (monosaccharides) link together.
- $H_2O$  (one molecule of water) is eliminated as H from one glucose joins with OH from the second glucose (ie) : condensation reaction.
  - H = Hydrogen.
  - OH = Hydroxyl group.

## POLYSACCHARIDES

- In other plants, the monosaccharides are arranged in chains (eg) : potato plant.



- Many monosaccharides link together and water is lost each time two monosaccharides link together (condensation reaction)
- FORMULA**  $\rightarrow (C_6H_{10}O_5)_n$ , n = number of monosaccharides in the polysaccharide chain.



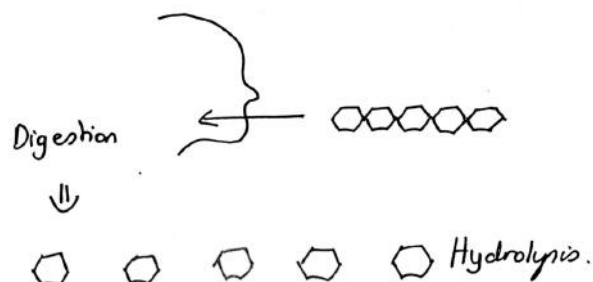
## EXAMPLES OF POLYSACCHARIDES

**Starch** : present in potatoes, cereals, rice pasta, vegetables, bread.

**Pectin** : gelling agent found in the walls of fruit (ripe fruit) (eg) : apples, blackcurrants.

**Glycogen** : store of glucose in humans and animals (found in liver)

**Dextrins** : when bread is toasted, the starch molecules near the surface brown = dextrins.



## CLASSIFICATION OF CARBOHYDRATES

- Carbohydrates may be classified according to :
  - A** : Food Source
  - B** : Chemical Structure

### A : FOOD SOURCE

Sugar	Jam, honey, sweets cakes, biscuits
Starch	Rice, bread, potatoes, cereals, pasta
Cellulose	fruit, vegetables, bran, whole cereals

**NOTE** : Cellulose may also be called fibre or roughage. It is an example of a non starch polysaccharide (NSP) – ie : cannot be digested by humans.

### B : CHEMICAL STRUCTURE

Monosaccharides	→ glucose → fructose → galactose
Disaccharides	→ Lactose → Maltose → sucrose
Polysaccharides	→ Starch → pectin → glycogen.

**NB** : DO NOT DRAW DIAGRAMS FOR CLASSIFICATION OF CARBOHYDRATES.



## ENERGY VALUE

- 1 gramme of carbohydrate when oxidized releases 4 kcals (16.8kJ) of energy.

## RDA OF CARBOHYDRATE

- NONE.
- Instead, the RDA varies on the energy needs of different people.
- The prominence of carbohydrate rich foods varies widely in different parts of the world. Consumption depends of availability and cost of protein & lipid foods and the amount of money that can be spent on food.
- In poor countries approximately 80% of total energy intake comes from carbohydrates (mainly starch)
- In wealthier countries (eg : Ireland), 50% of total energy intake is from carbohydrates.
- There is however an RDA for cellulose/fibre. Current nutritional guidelines suggest a daily intake of 25g of fibre.
- On average, Irish people only consume 18g of fibre per day.



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## NON STARCH POLYSACCHARIDE

- NSP
- They are polysaccharides that **cannot** be digested or broken down by the body.
- EXAMPLES :
  - Fibre (cellulose)
  - Pectin
  - Gums (guar gum, carob bean gum)

## NB : FIBRE

- NSP
- Also called cellulose or roughage.
- Forms the structural part of plants, outer skins and seed coverings, found in fruit, vegetables, nuts and cereals.
- Cannot be digested.
- Hygroscopic (absorbs six times its own weight in water)
- **RDA FIBRE** – 25g – 30g.

## FUNCTIONS OF FIBRE

### A : STIMULATES PERISTALSIS

- Fibre passes through the digestive tract undigested.
- However, it does have a key role (ie) : removal of waste (faeces) from the body.
- Fibre is mixed through faeces. Fibre absorbs water in the colon, as a result the fibre swells and therefore the faeces expands. This soft mass of waste pushes against the muscular walls of the colon/large intestine causing the muscles to contract and relax.
- This wave like motion is called Peristalsis, it causes waste to move along the colon and eventually leave the body via the back passage.



## B : FIBRE HELPS LOWER CHOLESTEROL

- Soluble fibre in oats, rye contains naturally occurring plant sterols.
- These plant sterols can block the absorption of cholesterol in the intestine so the cholesterol passes out of the body.
- **EXAMPLE** : Porridge is a good source of plant sterols.

## C : FIBRE ADDS 'BULK' TO THE DIET

- By including foods high in fibre to the diet, they can create a feeling of fullness without adding extra kilocalories to a meal.
- **EXAMPLE** : Homemade vegetable soup with lots of chunky vegetables. Adding mushrooms, peppers, tomatoes, to casseroles and Bolognese sauce. Good for people on low kilocalorie diets.

## FIBRE DEFICIENCY

### A : CONSTIPATION

- If there is a lack of fibre in the diet, the faeces remain hard in the colon as they cannot expand and stimulate peristalsis.
- As a result, the faeces can 'sit' for long periods of time in the colon → called constipation.

### B : DIVERTICULITIS

- If constipation occurs regularly over a number of years, pockets or distortions may form in the walls of the colon called 'diverticula' (the condition is called **diverticulitis**)
- Waste/faeces may lodge in these diverticula, accompanied by pain/discomfort



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## C : COLON CANCER

- If waste lodges in the diverticula, it can 'go off' and produce toxins.
- The toxins can in turn act as carcinogens, causing normal healthy cells to divide abnormally and produce a tumour.

## GLYCAEMIC INDEX

What is the Glycaemic Index?	Low GI factor	Medium GI factor	High GI factor
GI is a way of classifying carbohydrates according to the speed at which your body breaks them down and converts them to glucose to use as energy. The faster a food breaks down, the higher the GI factor (glucose has the highest GI factor of 100). Foods with a high GI are rapidly digested and absorbed and quickly raise blood sugar levels. Low GI factor foods are broken down and digested more slowly, so ensuring a slow and sustained release of glucose. Proteins and fats have little effect on blood sugar levels.  If you eat lots of high GI carbs, your body is effectively overloaded with glucose. To combat this, glucose is diverted to your bloodstream to be stored as fat. Calories are calories whether they come from fat, protein or carbs, but some experts believe that eating low GI foods may help the body burn fat more efficiently.	Apple Baked beans Carrots Cherries Chick peas Grapefruit Grapes Kidney beans Kiwi fruit Lentils Orange Peach Pear Peas Plum	Apricot Banana Beetroot Boiled potato Mango Pawpaw Pineapple Raisins Sultanas Sweet potato	Baked potato French fries Lychee Mashed potato Parsnip Swede

Source : BBC Good Food

### NOTE :

- Carbohydrate foods with a low GI are sometimes called 'complex carbohydrates' as they release glucose slowly into the blood stream. As long as glucose is trickling into the bloodstream, hunger pangs stay away.
- 'Brown foods' are complex carbohydrates (eg) : brown bread, brown rice, wholegrain pasta, whole cereals.



## BIOLOGICAL FUNCTIONS OF CARBOHYDRATES

SUGAR	STARCH	NON STARCH Polysaccharide
<ul style="list-style-type: none"> <li>Sugar provides energy for the body.</li> <li>excess is converted to glycogen (energy store)</li> <li>↓</li> <li>extra is converted to adipose tissue.</li> </ul>	<ul style="list-style-type: none"> <li>Starch provides energy for the body</li> <li>→ same</li> <li>saves protein from being used as a source of energy.</li> </ul>	<ul style="list-style-type: none"> <li>cellulose stimulates peristalsis in the colon.</li> </ul>

## CULLINARY FUNCTIONS OF CARBOHYDRATES

SUGAR	STARCH	NSP
<ul style="list-style-type: none"> <li>Sweetener in drinks, desserts, cereals.</li> <li>activates yeast during fermentation</li> <li>jam making</li> <li>icings and sweets</li> <li>Syrups in fruit salad</li> <li>aeration of creamed cakes</li> </ul>	<ul style="list-style-type: none"> <li>Used to thicken sauces, soups and gravies</li> <li>Dextrins (browning food)</li> <li>Food source for yeast → Baking</li> <li>Choux pastry → Starch gelatinises.</li> </ul>	<ul style="list-style-type: none"> <li>pectin is a gelling agent in jam making.</li> <li>Bulks out food eg. vegetables in a soup.</li> </ul>

## DIETARY GUIDELINES

- Dietary guidelines indicate that we should ...

(i) Ways to reduce sugar intake
<ul style="list-style-type: none"> <li>Choose unsweetened fruit drinks and buy fruit in its own juice <u>not</u> syrup.</li> <li>Choose unsweetened breakfast cereals <u>or</u> low sugar varieties</li> <li>Buy 'diet' carbonated drinks containing artificial sweeteners eg. Nutrasweet (Aspartame)</li> <li>Avoid adding sugar to tea/coffee</li> <li>Sweeten desserts with sweet fruits</li> <li>Modify recipes for desserts etc.</li> </ul>

(ii) Ways to increase fibre intake
<ul style="list-style-type: none"> <li>Choose brown rice instead of white rice.</li> <li>Replace white bread with wholemeal bread</li> <li>Choose high fibre breakfast cereals eg. 'All Bran', 'Fruit + Fibre'</li> <li>Leave skin on fruit eg. apples.</li> <li>add chopped fruit to yoghurt, breakfast cereals.</li> <li>add dried fruit and nuts to baked products.</li> <li>Include pulses &amp; nuts in more meals.</li> </ul>

NOTE : RDA FIBRE → 25g – 30g.



## GENERAL PROPERTIES OF CARBOHYDRATES

- Section A of the Home Economics paper has 12 short questions.
- Students **MUST** answer 10 questions @ 6 marks each.
- If the following terms appear, answer as follows :

### EXPLAIN THE FOLLOWING TERMS :

## 1 : CARMELISATION

- Form of non-enzymic browning.
- When sugars are heated above their melting points, they produce a range of brown substances known as caramel.
- Caramelisation occurs most readily in the absence of water (eg : Crème Brûlée) but sugar solutions (syrup) will caramelise if heated strongly enough.
- There are ten changes between melting of sugar and caramelisation (first stage @ 104°C, last stage ie : caramelisation @ 177°C)
- Avoid too much heat → bitter caramel.
- **USES IN COOKERY :**
  - Crème Brûlée
  - Caramel squares
  - Crème caramel

Crème Brûlée →



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## 2 : SWEETNESS

SUGAR	RELATIVE SWEETNESS
Fructose	170
Sucrose	100
Lactose	15

- All sugars are sweet (but do not have the same degree of sweetness)
- Using the tasting method the sweetness of different can be compared using a point scale in which sucrose is 100.
- Starch and other polysaccharides do not have a sweet taste.
- **USES IN COOKERY :**
  - Pavlova or meringue
  - Sprinkling sugar over fresh strawberries
  - To sweeten custards/cream.

Pavlova →



### 3 : SOLUBILITY

- This is the degree to which a substance will dissolve in a given solvent.
- Sugars (monosaccharides and disaccharides) are very soluble in cold water.
- Solubility is increased by heating water.
- Sugars form supersaturated syrups when their solutions are concentrated by evaporation as a result of boiling.
- **NOTE** : Starches and other polysaccharides are insoluble in water.
- **USES IN COOKERY** :
  - Fruit syrup in fruit salad.
  - Making ice cream (using a syrup)



### 4 : GELATINISATION

- If a mixture of starch and liquid is heated, the water penetrates the outer layers of the granules (starch) and the starch granules begin to swell.
- As the size of the granules increase, liquid is absorbed and the mixture becomes more viscous (ie) : thick and gluey.
- Initial gelatinization @ 55°C - 70°C (the liquid begins to thicken)
- Complete gelatinisation @ 100°C the mixture becomes more viscous as more liquid is absorbed forming what is called a **sol**.
- On cooling a sol forms a **gel**.
- Sol → Gel.
- **USES IN COOKERY** :
  - White sauce (lasagne)
  - Choux pastry (éclairs)
  - Fruit glaze (flan)



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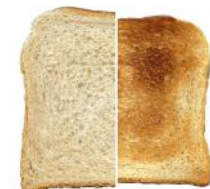
### 5 : CRYSTALLISATION

- Crystallisation usually occurs due to over concentration of sugar (normally 1:1 is used, fruit : sugar) ie : equal amounts of fruit and sugar. AVOID going above this 1:1 ratio.
- Too little acid and short cooking time of fruit and sugar, crystals will form (usually the shape of granulated sugar crystals)
- Too much acid cooked with fruit and sugar for too long, crystals will form (usually long needle shaped crystals)
- **USES IN COOKERY** :
  - Fudge making (due to high sugar concentration)  
**NOTE** : desirable effect in fudge.
  - Jam making (crystallisation may occur if basic rules for jam making are not followed)  
**NOTE** : undesirable effect in jam.



### 6 : DEXTRINISATION

- Effect of dry heat on starch.
- Non – enzymic browning.
- Most foods that contain starch (long polysaccharides of glucose) also contain small amounts of dextrins (short polysaccharides of glucose)
- On heating, dextrins polymerise to form longer chains and become brown coloured substances called pyrodextrins.
- Pyrodextrins give a brown colour and characteristic texture to many foods.
- **USES IN COOKERY** :
  - Toast
  - Bread crust





## 7 : INVERSION (HYDROLYSIS OF SUCROSE)

- Inversion of sucrose = hydrolysis of sucrose.

- Jam Making :**

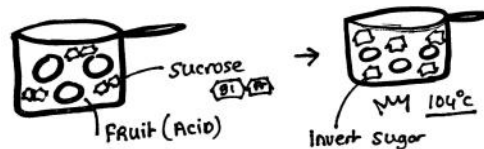
- Sucrose + Acid + Heat.
- Sugar + Lemon Juice + 104°C
- **RESULT** : sucrose splits (hydrolysis)
  - Produces fructose and glucose (invert sugar)



- **NOTE** : The presence of invert sugar in jam helps form a smooth gel.

- USES IN COOKERY :**

- Jam
- Boiled sweets



## 8 : GEL FORMATION (PROPERTY OF NSP)

- For example, in jam making.
- Gel formation depends on :
  - pH.
  - Amount of sugar.
  - Amount of pectin.
  - Quality of pectin.
- Pectin is found naturally between plant cells and cell walls of fruit (eg) : Blackcurrants/cooking apples have a high pectin content. Strawberries/rhubarb have a low pectin content.
- Heat must be used to extract pectin.
- The pH of jam must be around pH 3.5 (otherwise pectin chains come apart, preventing gel formation)
- A good gel is formed (minimum 65% sugar) usually 1:1 ratio of fruit : sugar.
  - Sugar brings the pectin chains together and binds up water so a gel structure can develop.
- **NOTE** : Pectin is found in **RIPE** fruit.

**NB** : Maillard reaction, see protein handout, can also apply to carbohydrates.



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## TO DO :

Enumerate the properties of ...

### A : SUGAR

\_\_\_\_\_(2)  
\_\_\_\_\_(2)  
\_\_\_\_\_(2)

### B : STARCH

\_\_\_\_\_(2)  
\_\_\_\_\_(2)  
\_\_\_\_\_(2)

**NB** : Include examples (1 + 1)

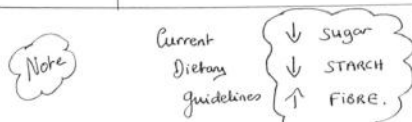
## PROPERTIES OF CARBOHYDRATES

PROPERTIES OF CARBOHYDRATES	
Sugar	<ul style="list-style-type: none"> <li>- Caramelisation</li> <li>- Sweetness</li> <li>- solubility</li> <li>- Inversion</li> <li>- crystallisation (fudge) *</li> </ul>
Starch	<ul style="list-style-type: none"> <li>- Dextrinisation</li> <li>- gelatinisation</li> <li>- Hygroscopic</li> <li>- No sweet taste.</li> </ul>
NSP	<ul style="list-style-type: none"> <li>- Hygroscopic.</li> <li>- insoluble in water</li> <li>- pectin forms a gel with water</li> </ul>

## PROPERTIES OF NSP

- Cellulose is hygroscopic (absorbs 6X its own weight in water)
- Pectin forms a gel with sugar.
- NSP are insoluble in water.

Property	Description	Uses in Cookery
(i) Hygroscopic (cellulose)	<ul style="list-style-type: none"> <li>Cellulose is able to absorb up to 6 times its own weight in water.</li> <li>as water is absorbed, cellulose softens.</li> </ul>	<ul style="list-style-type: none"> <li>cooking vegetables</li> <li>cooking fruit. (eg. fruit tarts and crumbles)</li> </ul>
(ii) insoluble in water	<ul style="list-style-type: none"> <li>all non starch polysaccharides are insoluble in water</li> </ul>	<ul style="list-style-type: none"> <li>Fruit and vegetables do not dissolve during cooking! (However they may shrink eg. roasting or disintegrate eg. stewed apple)</li> </ul>



## SAMPLE ANSWERS

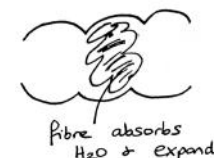
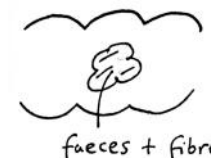
### 2016 Q1(B) HIGHER LEVEL (15 MARKS)

(c) Evaluate the benefits of a diet rich in fibre.

(15)

#### A : STIMULATES PERISTALSIS (5 MARKS)

- Fibre passes through the digestive tract undigested.
- However, it does have a key role (ie) : removal of waste (faeces) from the body.
- Fibre is mixed through faeces. Fibre absorbs water in the colon, as a result the fibre swells and therefore the faeces expands. This soft mass of waste pushes against the muscular walls of the colon/large intestine causing the muscles to contract and relax.
- This wave like motion is called Peristalsis, it causes waste to move along the colon and eventually leave the body via the back passage.



#### B : FIBRE HELPS LOWER CHOLESTEROL (5 MARKS)

- Soluble fibre in oats, rye contains naturally occurring plant sterols.
- These plant sterols can block the absorption of cholesterol in the intestine so the cholesterol passes out of the body.
- EXAMPLE** : Porridge is a good source of plant sterols.

#### C : FIBRE ADDS 'BULK' TO THE DIET (5 MARKS)

- By including foods high in fibre to the diet, they can create a feeling of fullness without adding extra kilocalories to a meal.
- EXAMPLE** : Homemade vegetable soup with lots of chunky vegetables. Adding mushrooms, peppers, tomatoes, to casseroles and Bolognese sauce. Good for people on low kilocalorie diets.



## 2016 Q1(B) HIGHER LEVEL (9 MARKS)

- (d) Name **and** give an account of **one** bowel disease.  
Refer to symptoms / effects.

(9)

### DIVERTICULITIS (2 MARKS)

- If constipation occurs regularly over a number of years, pockets or distortions may form in the walls of the colon called 'diverticula' (the condition is called **diverticulitis**) (2M)
- Waste/faeces may lodge in these diverticula (2M), accompanied by pain/discomfort, nausea, vomiting, bloating (3M).



## 2017 Q1(B) HIGHER LEVEL (15 MARKS)

- (b) Classify *carbohydrates*.  
With reference to **each** class give:

- the chemical formula
- examples
- food source.

(15)

Monosaccharides	$C_6 H_{12} O_6$	Glucose (apple)
Disaccharides	$C_{12} H_{22} O_{11}$	Lactose (milk)
Polysaccharides	$(C_6 H_{10} O_5)_n$	Starch (potatoes) Pectin (blackcurrant)



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## 2017 Q1(B) HIGHER LEVEL (15 MARKS)

- (c) Explain **three** properties of sugar and the related culinary use of each.

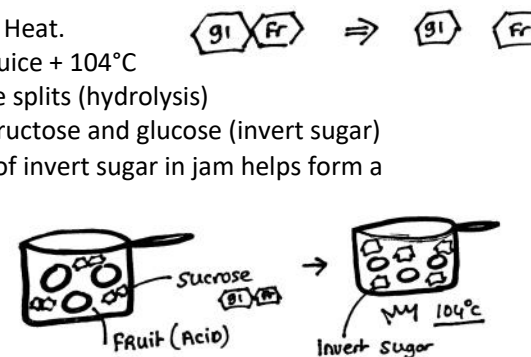
(15)

### 1 : CARMELISATION (5 MARKS)

- Form of non-enzymic browning.
- When sugars are heated above their melting points, they produce a range of brown substances known as caramel.
- Caramelisation occurs most readily in the absence of water (eg : Crème Brûlée) but sugar solutions (syrup) will caramelize if heated strongly enough.
- There are ten changes between melting of sugar and caramelisation (first stage @ 104°C, last stage ie : caramelisation @ 177°C)
- Avoid too much heat → bitter caramel.
- USES IN COOKERY :**
  - Crème Brûlée
  - Caramel squares
  - Crème caramel

### 2 : INVERSION (5 MARKS)

- Inversion of sucrose = hydrolysis of sucrose.
- Jam Making :**
  - Sucrose + Acid + Heat.
  - Sugar + Lemon Juice + 104°C
  - RESULT :** sucrose splits (hydrolysis)
    - Produces fructose and glucose (invert sugar)
- NOTE :** The presence of invert sugar in jam helps form a smooth gel.
- USES IN COOKERY :**
  - Jam
  - Boiled sweets



### 3 : MAILLARD REACTION – (PROTEIN NOTES) (5 MARKS)

- Foods containing both amino acids and sugar are subjected to dry heat (eg) : oven/grill.
- The OH (hydroxyl group) of the sugar chemically reacts with the NH<sub>2</sub> (amino group) of the amino acid.
- **RESULT** → Food browns.
- **USES IN COOKERY** :
  - Sponge cake

## HOMEWORK

### 2017 Q1(B) HIGHER LEVEL (10 MARKS)

- (d) Assess the effects of high sugar consumption on the body.

(10)

### 2012 Q1(B) HIGHER LEVEL (24 MARKS)

- (b) Give an account of carbohydrates and refer to:

- the chemical structure of a monosaccharide
- the formation of disaccharides
- the hydrolysis of sugar to include inversion.

(24)



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## SHORT QUESTIONS

### 2011 SQ1 HIGHER LEVEL (6 MARKS)

1. Complete the following table in relation to carbohydrates.

(6)

Classification	Example	Food Source
Monosaccharides	FRUCTOSE	Honey
Disaccharides	SUCROSE	TABLE SUGAR
Polysaccharides	STARCH	PASTA

### 2010 SQ2 HIGHER LEVEL (6 MARKS)

2. Name three properties of sugar and state one culinary use of each.

(6)

Property	Culinary use
1. INVERSION	Jam Making
2. Caramelisation	Crème Brûlée
3. Sweetness	Pastry

### 2009 SQ1 HIGHER LEVEL (6 MARKS)

1. In relation to carbohydrate explain the property *dextrinisation*.

(6)

Non enzymic browning of food, 2009  
Dextrins are short polysaccharides of glucose on the surface of bread, raw dough, when exposed to dry heat pyrodextrins are formed which have a brown colour and characteristic crunchy texture eg. Toast.

### 2004 SQ4 HIGHER LEVEL (6 MARKS)

4. (a) Name the **three** main nutrients found in the endosperm of the wheat grain. (3)

(i) STARCH (ii) LBV Protein (iii) calcium

- (b) Explain the term *gelatinisation*. (3)

The thickening of a liquid due to the presence of starch and heat, initial gelatinisation 55°C - 70°C where the liquid begins to thicken, complete gelatinisation 100°C when the liquid is fully thickened, eg. Roux sauce (white sauce)

## PAST QUESTIONS

### 2007 Q1(B) HIGHER LEVEL (12 MARKS)

- (b) In relation to starch, explain **each** of the following:

- (i) gelatinisation  
(ii) dextrinisation.

(12)

### 2005 Q1(B) HIGHER LEVEL (24 MARKS)

- (b) Describe the chemical structure of **each** of the following:

- (i) monosaccharides  
(ii) disaccharides  
(iii) polysaccharides.

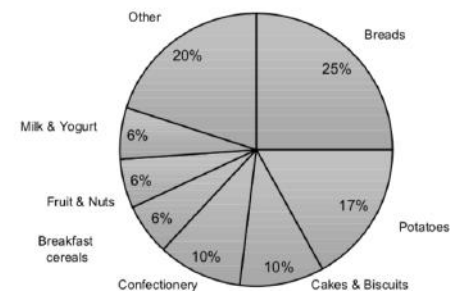
Give **one** example of each.

(24)

### 2005 Q1(B) HIGHER LEVEL (18 MARKS)

1. A recent survey found the main sources of carbohydrate in the Irish diet are as illustrated below.

Main Sources of Carbohydrate in the Irish Diet



(North-South Food Consumption Survey, 2001)

- (a) Using the information provided in the chart, and having regard to current healthy eating guidelines, suggest **three** ways that the food sources of carbohydrates in the diet should be adjusted.  
Give a reason for **each** suggestion.

(18)

