# 1.2 Lipids and ester bonds

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

**KEY WORDS** triglyceride • ester bond • saturated • unsaturated • emulsion

## Objective

Practise statement 1.5: triglyceride synthesis, ester bonds, and the saturated/unsaturated distinction that links lipid chemistry to diet and cardiovascular risk.

## 1 Key knowledge and worked examples

### ■ One glycerol, three fatty acids, three ester bonds

A **triglyceride** forms when glycerol's three hydroxyl groups each condense with the carboxyl group of a fatty acid, releasing three water molecules and forming three **ester bonds** .

### ■ Saturation decides packing

A **saturated** fatty acid has no C=C: the chain is straight, chains pack closely, and the fat is solid at room temperature (butter). An **unsaturated** acid has one or more C=C, each forcing a kink: packing is loose and the oil is liquid (olive oil). More energy per gram than carbohydrate because the molecule is more reduced – that is why seeds and adipose tissue store lipid.

### ■ Worked example: designing the emulsion test comparison

To compare the lipid content of two milks: equal volumes of each + equal ethanol, shake, decant the ethanol into equal volumes of cold water. A cloudy white **emulsion** means lipid present. Compare turbidity between the two tubes – the milk giving the denser emulsion carries more lipid. Controls: same volumes, same temperature, same water volume; repeat with three samples each.

## 2 Practice

**2.1** Describe how a triglyceride is synthesised, naming the reactants, the type of reaction and the bond formed. [3]

**2.2** Oleic acid contains one C=C bond per chain and stearic acid contains none. Explain which fat solidifies at the lower temperature. [2]

**2.3** State one advantage of storing energy as triglyceride rather than glycogen. [1]

## 3 Exam-style questions

**3.1** The table shows the percentage of fatty acids in three dietary fats.

| Fat | Saturated / % | Monounsaturated / % | Polyunsaturated / % |
|---|---|---|---|
| Butter | 51 | 21 | 3 |
| Olive oil | 14 | 73 | 8 |
| Sunflower oil | 10 | 20 | 66 |

Use your knowledge of fatty-acid structure to explain why butter is solid at room temperature while sunflower oil is liquid, and suggest which fat a doctor might recommend to a patient with high blood LDL-cholesterol. Justify your answer. [5]

**3.2** A triglyceride contains the fatty acids C17H33COOH, C17H35COOH and C17H35COOH. Determine how many of the three fatty-acid chains are unsaturated, state the total number of water molecules released when this triglyceride forms, and name the bonds that link the fatty acids to glycerol. [4]

**3.3** Adipose tissue stores triglyceride but muscle stores glycogen. Explain this difference by comparing energy per gram and the effect on cell water potential, and state one situation in which the body preferentially mobilises lipid rather than glycogen. [5]

## Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

**2.1** Glycerol and three fatty acids join in condensation reactions forming ester bonds between each fatty acid and the glycerol.

**2.2** Stearic acid (no C=C) solidifies at the higher, not lower, temperature – its straight chains pack closely, so more energy is needed to separate them. Oleic acid's kinked chains pack loosely, so it is liquid at a lower temperature.

**2.3** Any one: more energy per gram; insoluble so no effect on cell water potential; more compact per unit energy.

**3.1** Butter's high saturated proportion means straight chains packing tightly – solid at room temperature. Sunflower oil's polyunsaturated chains carry several kinks, preventing close packing – liquid. Olive oil, rich in monounsaturates, is the usual recommendation for high LDL-cholesterol because replacing saturated fat with monounsaturated fat lowers LDL while keeping HDL; sunflower oil is also acceptable with the same justification via polyunsaturates.

**3.2** A saturated 18-carbon fatty acid is C17H35COOH (fully hydrogenated); C17H33COOH has two fewer H, so one C=C – unsaturated. One unsaturated chain. Three water molecules released, one per ester bond formed.

**3.3** Triglyceride yields more ATP per gram (about twice carbohydrate) and, being non-polar and insoluble, does not lower cell water potential the way dissolved glycogen would. Glycogen's advantage is speed – it is mobilised first during intense exercise. Lipid is preferentially mobilised during prolonged low-intensity activity or fasting, when glycogen stores fall.