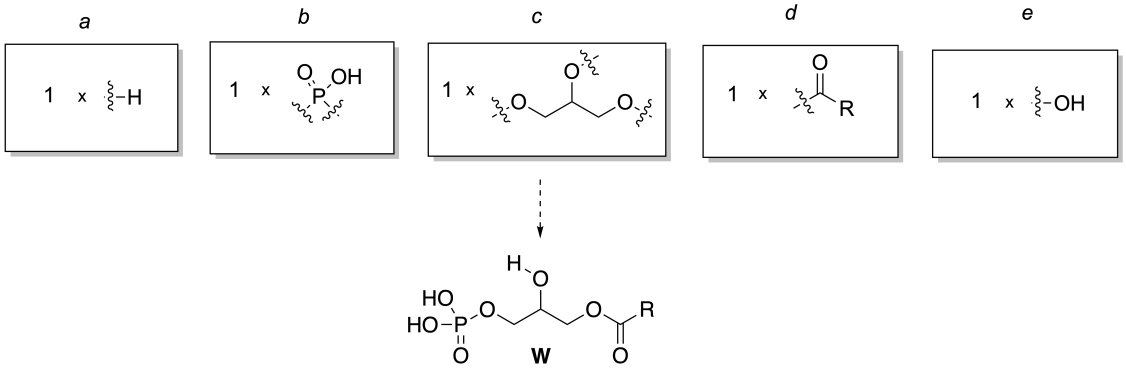
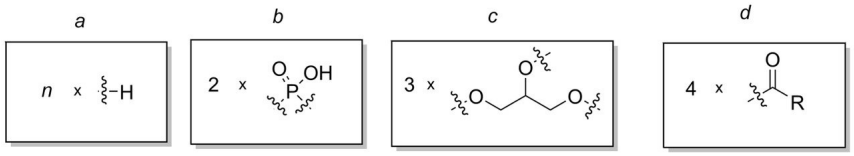
T5. Cardiolipins

6%						
5.1	5.2	5.3	5.4	5.5	5.6	Σ
1	6	4	2	2	3	18

In this problem you are asked to be creative and build molecules from fragments. For instance, if you are required to draw a chiral phospholipid such as **W** using fragments *a*-*e*, it can be assembled as shown below.



Cardiolipins are a family of acyclic phospholipids differing in fatty acid residues. They are essential for energy production and membrane stability. Defects can lead to certain diseases. **PL1** belongs to this family. Using only the structural elements *a*-*d* in the quantities stated below, it is possible to assemble the non-ionised form of **PL1**. R is a hydrocarbon substituent in the fatty acid structure.



PL1 does not contain any peroxide bonds.

5.1 **Tick** one correct statement regarding the value of *n* (number of type *a* fragments). 1.0 pt

(a) *n* is an even number,
(b) *n* is an odd number,
(c) *n* can be either an odd or an even number.

Some cardiolipins are chiral molecules, even if they contain four identical fatty acid residues, as in the case of **PL1**. One enantiomer of **PL1** is found in prokaryotes and eukaryotes, and the other only in archaea. All other diastereomers of **PL1** are achiral molecules, since they have a plane of symmetry. Do not consider the chirality of phosphorus atoms as stereocentres.

PL1 is a diprotic acid with the same acidic groups. Its second deprotonation is less favourable ($pK_{a2} \gg pK_{a1}$) due to the special, stable structure of monoanion **Y**.

5.2 **Draw** the structure of one enantiomer of **PL1. Draw** the structure of **Y** in a way that shows the stabilisation that explains the difference between pK_{a1} and pK_{a2}. Use the abbreviation R for the fatty acid residues. 6.0 pt

A series of experiments was conducted to identify the fatty acid (RCOOH) in **PL1** found predominantly in mammalian hearts. During reductive ozonolysis, RCOOH forms three different organic products in equimolar amounts.

5.3 **Determine** the molecular formula of the fatty acid (RCOOH), if the non-ionised form of **PL1** contains 255 σ and π bonds between atoms in total. **Support** your answer with calculations. 4.0 pt

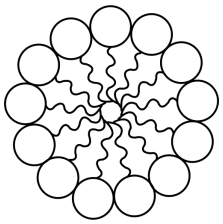
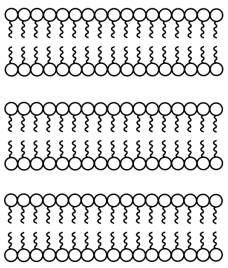
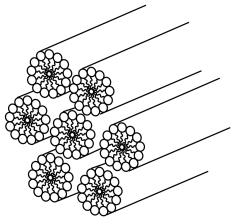
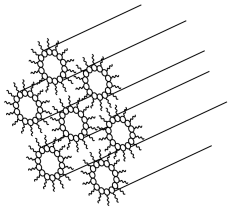
If you were unable to find the structural formula of **PL1**, *you can use a-d fragments from* **5.1**.

100 g of RCOOH reacts with 181.0 g of iodine. RCOOH also reacts in similar way with **X** and forms an adduct with an iodine mass fraction of 36.57%.

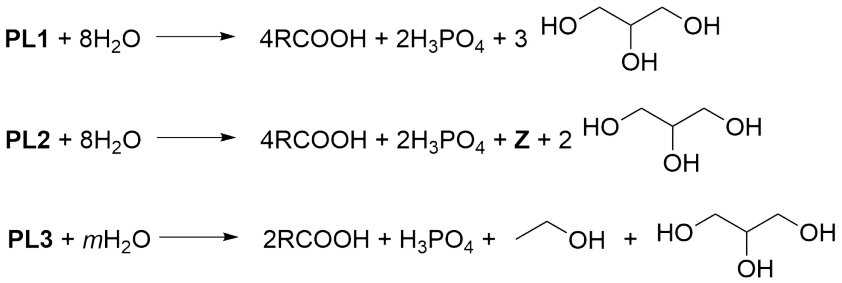
5.4 **Determine** the molecular formula of **X**. **Support** your answer with calculations. 2.0 pt

The phase behavior of **PL1** depends on pH. In physiological conditions, **PL1** is a dianion and it forms a lamellar phase.

5.5 Which lipid phase is formed by **PL1** when both acid residues in it are protonated? Note that knowledge of **PL1** structure is not required to solve this question. **Tick** the correct answer. 2.0 pt

			
(a) micellar	(b) lamellar	(c) hexagonal	(d) inverse hexagonal

The following balanced reaction equations show the hydrolysis of phospholipids **PL1**-**PL3**:



- The non-ionised form of **PL2** contains 254 σ and π bonds between atoms in total. It is a chiral and a more symmetrical molecule than **PL1**,

- **Z** contains C, H, and O only, and it doesn't react with H_2 in the presence of a catalyst,

- Phospholipid **PL3** is a charged molecule at physiological pH values, and it exists as pair of enantiomers.

5.6 **Draw** the structures of **PL2** and **PL3** using R to show the fatty acid residues. 3.0 pt
Show stereochemistry where appropriate.