Q1 **(a) (i)** Write the equation for a reaction in which ethylamine, $C_2H_5NH_2$, acts as a Brønsted-Lowry base.

.....

(ii) Ammonia, ethylamine and phenylamine, $C_6H_5NH_2$, are three nitrogen-containing bases. Place these three compounds in order of basicity, with the most basic first.

most basic		least basic

(iii) Explain why you have placed the three compounds in this order.

.....

.....

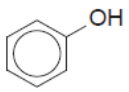
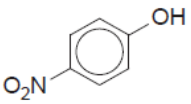
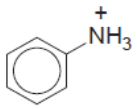
.....

.....[4]

(b) (i) Write an equation for a reaction in which phenol, C_6H_5OH, acts as a Brønsted-Lowry acid.

.....

The pK_a values for phenol, 4-nitrophenol and the phenylammonium ion are given in the table.

compound	pK_a
	10.0
	7.2
	4.6

(ii) Suggest an explanation for the difference in the pK_a values of phenol and nitrophenol.

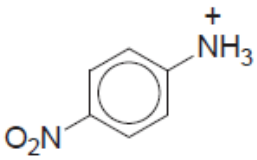
.....

.....

.....

.....

(iii) Using the information in the table opposite, predict which of the following pK_a values is the most likely for the 4-nitrophenylammonium ion.



Place a tick (✓) in the box beside the value you have chosen.

pK_a	
1.0	
4.5	
7.0	
10.0	

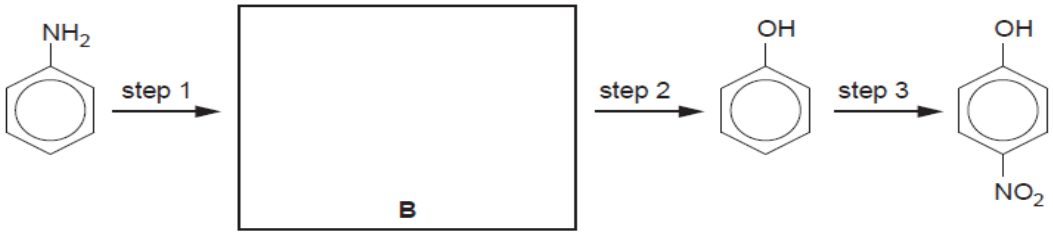
(iv) Explain your answer to part **(iii)**.

.....

.....

.....[5]

(c) Phenylamine can be converted to 4-nitrophenol by the following steps.

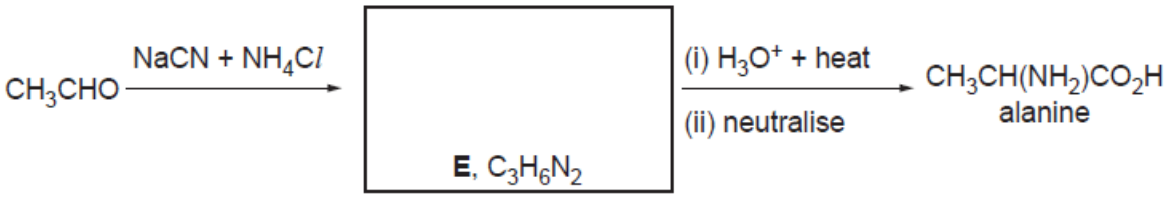


(i) Suggest the identity of intermediate **B** by drawing its structure in the box above.
(ii) Suggest reagents and conditions for the three steps in the above scheme.

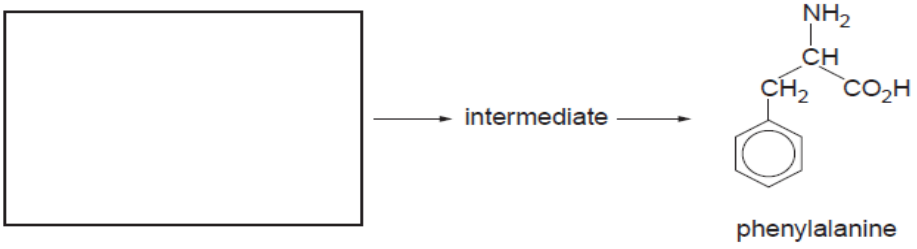
	reagent(s)	conditions
step 1		
step 2		
step 3		

(Nov 2011 P42 Q4)

Q2 **(a)** Amino acids such as alanine are essential building blocks for making proteins. They can be synthesised by a general reaction of which the following is an example.



(i) Suggest the structure of the intermediate compound **E** by drawing its structural formula in the box above.
(ii) Suggest, in the box below, the structural formula of the starting material needed to synthesise phenylalanine by the above general reaction.



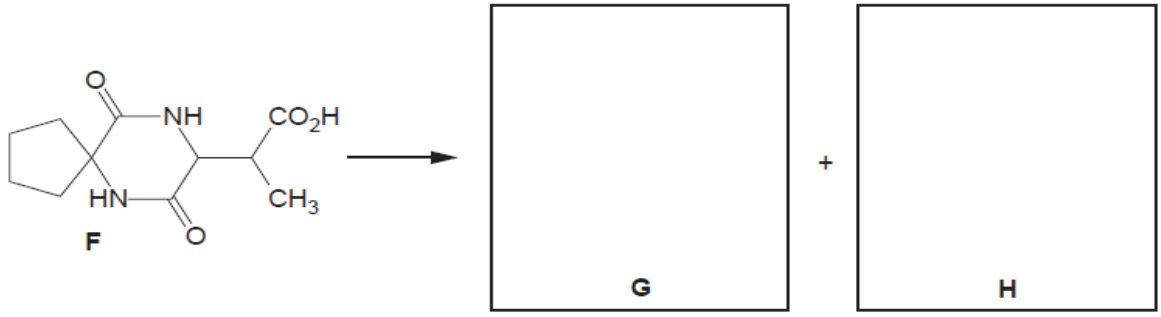
(b) (i) What is a *protein*?

.....

(ii) Using alanine as an example, draw a diagram to show how proteins are formed from amino acids. Show two repeat units in your answer.

[3]

(c) The hydrolysis of compound **F** produces two compounds **G** and **H**.



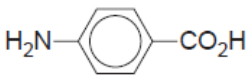
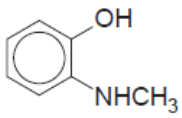
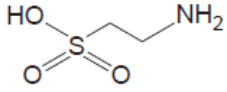
(i) State the reagents and conditions needed for this hydrolysis.

.....

(ii) Draw the structures of the two products **G** and **H** in the boxes above. [3]

(d) (i) Draw the zwitterionic structure of alanine.

(ii) Suggest the structural formulae of the zwitterions that could be formed from the following compounds.

compound	zwitterion
	
	
	

(e) Solutions of amino acids are good buffers.

(i) What is meant by the term *buffer*?

.....

(ii) Write an equation to show how a solution of alanine, $CH_3CH(NH_2)CO_2H$, behaves as a buffer in the presence of an acid such as HC*l*(aq).

.....

(iii) Briefly describe how the pH of blood is controlled.

.....

.....

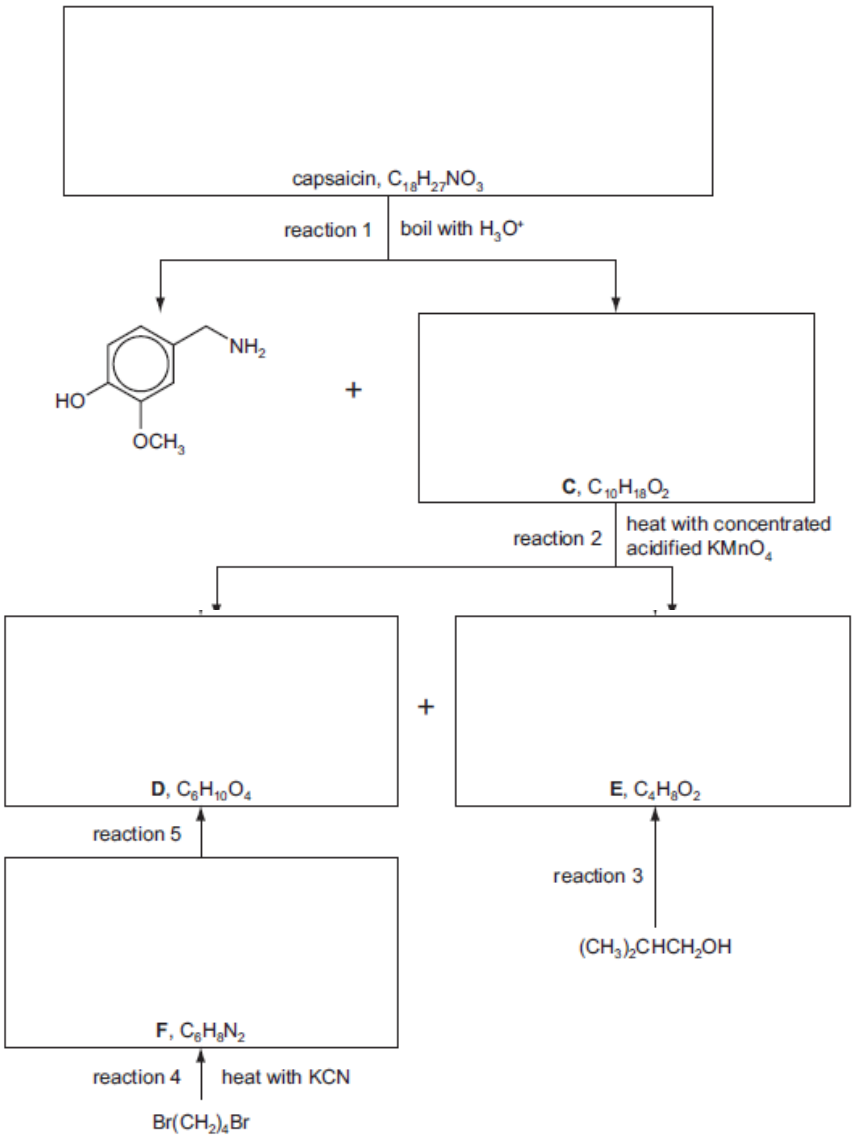
.....

(iv) Calculate the pH of the buffer formed when 10.0 cm^3 of 0.100 mol dm^{-3} NaOH is added to 10.0 cm^3 of 0.250 mol dm^{-3} CH_3CO_2H, whose pK_a = 4.76.

pH = ...[7]

(Nov 2011 P43 Q3)

Q3 The compound responsible for the hot taste of chilli peppers is capsaicin. Its molecular structure can be deduced by the following reaction scheme.



Compounds **C**, **D** and **E** all react with Na_2CO_3(aq).

(a) Suggest reagents and conditions for reaction 3.

..... [1]

(b) What *type of reaction* is reaction 4?

..... [1]

(c) Suggest reagents and conditions for reaction 5.

..... [1]

(d) Name the functional group in **C** that has reacted with hot concentrated acidifi ed $KMnO_4$.

..... [1]

(e) Suggest the name of the functional group in capsaicin that has reacted in reaction 1.

..... [1]

(f) Work out structures for compounds **C**–**F** and capsaicin, and draw their structural formulae in the boxes opposite. [5]

(Nov 2012 P41 Q4)

Q4 (a) (i) Explain why ethylamine is basic.

.....

.....

(ii) Write an equation showing ethylamine acting as

a base, ...

a nucleophile. .....

(iii) Why is phenylamine less basic than ethylamine?

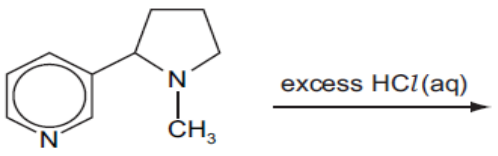
.....

.....

.....

Alkaloids are naturally-occurring compounds that act as bases.

(iv) Suggest the structure of the product, **E**, of the reaction between the alkaloid nicotine and an excess of HC*l* (aq).



nicotine

excess HC*l*(aq) →

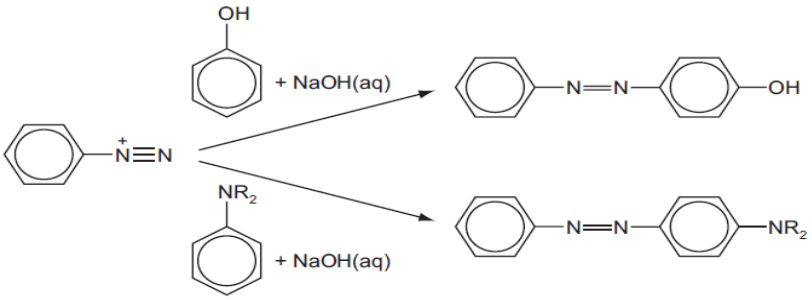
E

(b) Phenylamine, and substituted phenylamines, are used to make cloth dyes and food colourants. The first step in this process is the production of a diazonium salt.

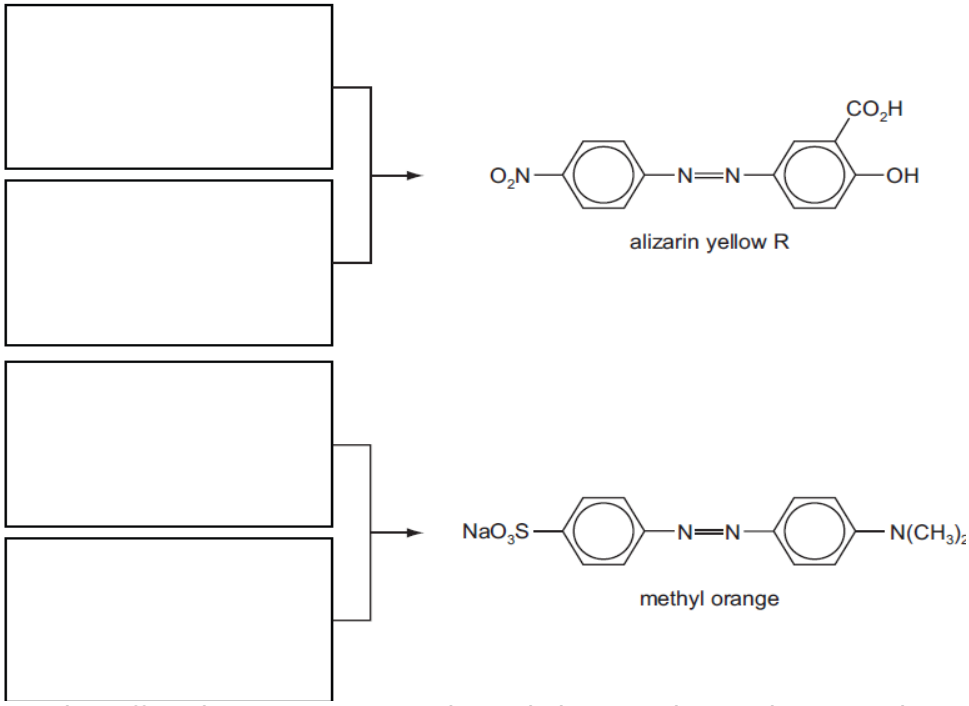
(i) State the reagents and conditions necessary for this reaction.

.....

The diazonium salt is then reacted with a phenol or an aryl amine in alkaline solution.



(ii) Suggest the starting materials needed to synthesise the following dyes.
Draw their structures in the boxes provided.



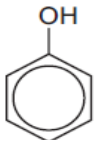
(iii) Suggest what effect the NaO_3S – group in methyl orange has on its properties. This group has no effect on the colour of the compound.

.....

(Nov 2012 P43 Q5)

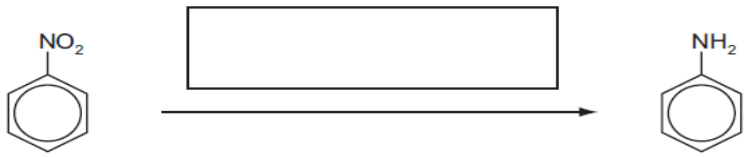
Q5 **(a)** Describe the reagents and conditions required to form a nitro compound from the following.

(i) methylbenzene  .....

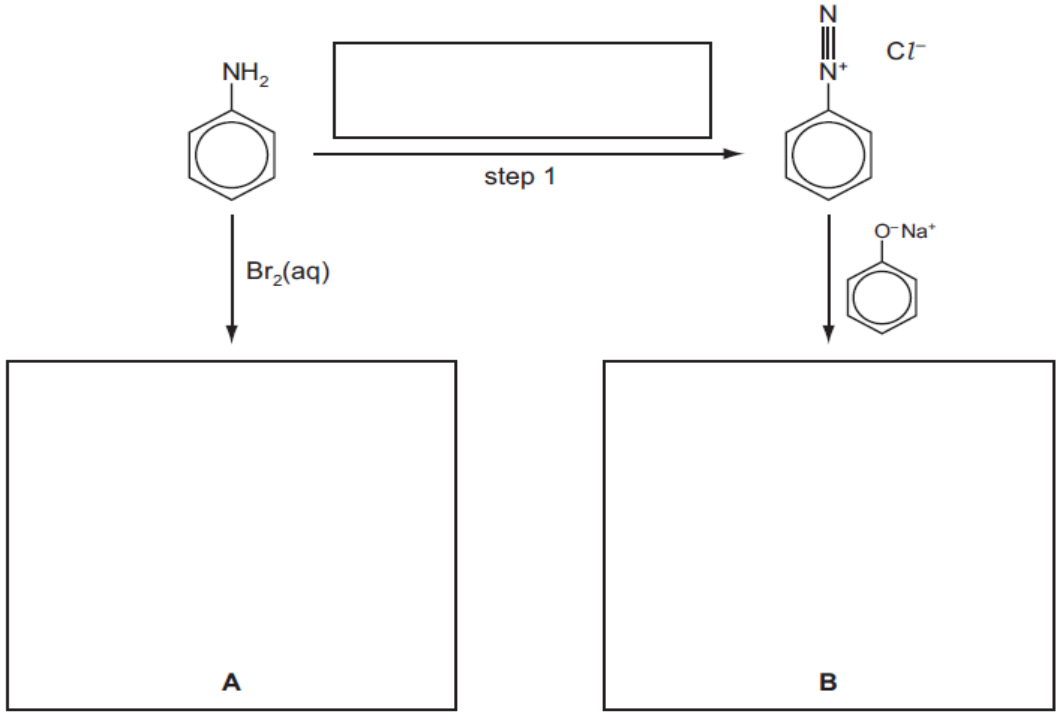
(ii) phenol  .....

(b) Draw the structure of the intermediate organic ion formed during the nitration of benzene.

(c) In the box over the arrow below, write the reagents needed to convert nitrobenzene into phenylamine.



(d) Phenylamine can be converted into the organic compounds **A** and **B**.
(i) Suggest the structural formulae of **A** and **B** in the boxes below.
(ii) Suggest suitable reagents and conditions for step 1, and write them in the box over the arrow.



(e) When phenylamine is treated with propanoyl chloride a white crystalline compound, **C**, $C_9H_{11}NO$, is formed.
(i) Name the functional group formed in this reaction. …….....
(ii) Calculate the percentage by mass of nitrogen in **C**.

percentage = ... %

(iii) Draw the structural formula of **C**.

(June 2013 P42 Q3)