Q1. This question is about several Brønsted–Lowry acids and bases.

(a) Define the term *Brønsted–Lowry* acid.

.....

.....

(1)

(b) Three equilibria are shown below. For each reaction, indicate whether the substance immediately **above** the box is acting as a Brønsted–Lowry acid (**A**) or a Brønsted–Lowry base (**B**) by writing **A** or **B** in each of the six boxes.

(i) CH_3COOH + H_2O ⇌ CH_3COO^- + H_3O^+

(1)

(ii) CH_3NH_2 + H_2O ⇌ $CH_3NH_3^+$ + OH^-

(1)

(iii) HNO_3 + H_2SO_4 ⇌ $H_2NO_3^+$ + HSO_4^-

(1)

(c) A 25.0 cm^3 sample of 0.0850 mol dm^{-3} hydrochloric acid was placed in a beaker. Distilled water was added until the pH of the solution was 1.25.

Calculate the total volume of the solution formed. State the units.

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)

(d) At 298 K, the value of the acid dissociation constant (K_a) for the weak acid HX in aqueous solution is 3.01×10^{-5} mol dm^{-3}.

(i) Calculate the value of pK_a for HX at this temperature.
Give your answer to 2 decimal places.

.....

.....

(1)

(ii) Write an expression for the acid dissociation constant (K_a) for the weak acid HX.

.....

.....

.....

(1)

(iii) Calculate the pH of a 0.174 mol dm^{-3} solution of HX at this temperature.
Give your answer to 2 decimal places.

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)

(e) An acidic buffer solution is formed when 10.0 cm^3 of 0.125 mol dm^{-3} aqueous sodium hydroxide are added to 15.0 cm^3 of 0.174 mol dm^{-3} aqueous HX.
The value of K_a for the weak acid HX is 3.01×10^{-5} mol dm^{-3}.

Calculate the pH of this buffer solution at 298 K.
Give your answer to 2 decimal places.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

.....

.....

.....

(6)

(Total 18 marks)

Q2. Ammonia and ethylamine are examples of weak Brønsted–Lowry bases.

(a) State the meaning of the term *Brønsted–Lowry base*.

.....

.....

(1)

(b) (i) Write an equation for the reaction of ethylamine ($CH_3CH_2NH_2$) with water to form a weakly alkaline solution.

.....

.....

(1)

(ii) In terms of this reaction, state why the solution formed is **weakly** alkaline.

.....

.....

(1)

(c) State which is the stronger base, ammonia or ethylamine. Explain your answer.

Stronger base .....

Explanation .....

.....

.....

.....

(Extra space) .....

.....

(3)

(d) Give the formula of an organic compound that forms an alkaline buffer solution when added to a solution of ethylamine.

.....

(1)

(e) Explain qualitatively how the buffer solution in part (d) maintains an almost constant pH when a small amount of hydrochloric acid is added to it.

.....

.....

.....

.....

(Extra space) .....

.....

(2)
(Total 9 marks)

Q3. When iron(II) sulfate is used for killing weeds in lawns, it is often mixed with the fertiliser ammonium sulfate. Ammonium sulfate also makes the soil acidic.

(a) Write an equation to show how the ammonium ion behaves as a Brønsted–Lowry acid in water.

.....

(1)

(b) Compounds such as ammonium sulfate react on warming with sodium hydroxide solution as shown in the equation below.

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_3 + 2H_2O$$

Use this information to describe a simple test, other than smell, to show that ammonia is evolved. State what you would observe.

Test .....

.....

Observation .....

(2)
(Total 3 marks)

Q4. In which one of the following reactions is the role of the reagent stated correctly?

	Reaction	**Role of reagent**
A	$TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$	TiO_2 is an oxidising agent
B	$HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$	HNO_3 is a Brønsted-Lowry acid
C	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	$AlCl_3$ is a Lewis base
D	$2CO + 2NO \rightarrow 2CO_2 + N_2$	CO is a reducing agent

(Total 1 mark)

Q5.

Summarised directions for recording responses to multiple completion questions			
A (i), (ii) and (iii) correct only	**B** (i) and (iii) correct only	**C** (ii) and (iv) correct only	**D** (iv) alone correct

Brønsted-Lowry acid-base reactions include

(i) $OH^- + CH_3Cl \rightarrow CH_3OH + Cl^-$

(ii) $NH_3 + HCl \rightarrow NH_4^+ + Cl^-$

(iii) $KF + PF_5 \rightarrow K^+ + PF_6^-$

(iv) $H_2O + H_2O \rightarrow H_3O^+ + OH^-$

(Total 1 mark)