8.1 Theories & Reactions of Acids & Bases

Question Paper

Course	DP IB Chemistry
Section	8. Acids & Bases
Topic	8.1 Theories & Reactions of Acids & Bases
Difficulty	Medium

Time allowed: 40

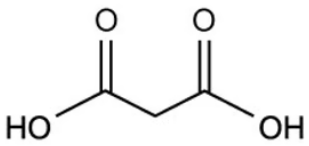
Score: /33

Percentage: /100

Question 1a

a) Malonic acid is a naturally occurring acid found in fruits and vegetables and is shown in **Figure 1** below.

Figure 1



The first dissociation of malonic acid is:

$$C_3H_4O_4\ (aq) + H_2O\ (l) \rightleftharpoons C_3H_3O_4^-\ (aq) + H_3O^+\ (aq)$$

Identify one conjugate acid-base pair from the equation.

[1 mark]

Question 1b

b) The anion $C_3H_3O_4^-$ may be classified as *amphiprotic*. Explain the meaning of *amphiprotic* and write equations, using $C_3H_3O_4^-$, to illustrate your answer.

[3 marks]

Question 1c

c) Write an equation to show how malonic acid reacts with magnesium.

[1 mark]

Question 1d

d) Under the right conditions, malonic acid can react with ethanol to form diethyl malonate, a diester.

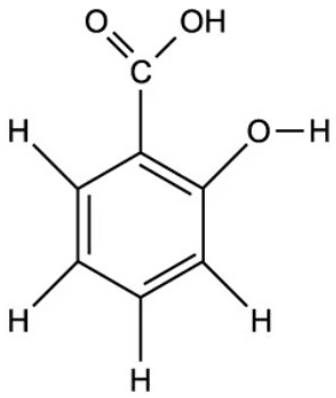
Draw a displayed formula for diethyl malonate showing all the bonds.

[1 mark]

Question 2a

a) Salicylic acid has the structure shown below in **Figure 1**.

Figure 1



Draw the structure of the conjugate base of salicylic acid, showing **all** the atoms and **all** the bonds.

[1 mark]

Question 2b

b) Predict what would be seen if a small amount of copper(II) oxide was added to an aqueous solution of salicylic acid, HOC_6H_4COOH, and warmed.

Write a balanced equation for the reaction.

[2 marks]

Question 2c

c) Suggest, with a reason, whether salicylic acid is likely to be soluble in water.

[1 mark]

Question 2d

d) Determine the relative molecular mass, M_r, of salicylic acid using Table 6 from the Data book.

[1 mark]

Question 3a

a) Write balanced equations to show the separate reactions between ethanoic acid and calcium carbonate, $CaCO_3$, magnesium oxide, MgO, and aluminium hydroxide, $Al(OH)_3$.

[3 marks]

Question 3b

b) In **Table 1** below, suggest the names and formulae of the acids and bases needed to make the specified salts.

Table 1

Acid	Base	Salt
		Copper nitrate, $Cu(NO_3)_2$
		Calcium phosphate, $Ca_3(PO_4)_2$

[2 marks]

Question 3c

c) The ethanoate ion, CH_3COO^- , carbon dioxide, CO_2, and the ethoxide ion, $CH_3CH_2O^-$, all contain carbon oxygen bonds.

Deduce the order in carbon to oxygen bond length from shortest to longest and explain your answer.

[3 marks]

Question 3d

d) Ethanoic acid, CH_3COOH, shows two absorptions in an infrared spectrum that are not present in the spectrum of ethanol.

Using Table 26 of the Data book, state the wavenumber range of these absorptions and the bonds that cause them.

[2 marks]

Question 4a

a) Glycolic acid, $C_2H_4O_3$, is a colourless, odourless crystalline solid that is highly soluble in water and behaves as a Brønsted–Lowry acid.

i) Define the term Brønsted–Lowry acid.

ii) State one difference between Brønsted–Lowry acids and the traditional theory of acids as substances that dissociate in water to form hydrogen ions.

[2 marks]

Question 4b

b) The systematic IUPAC name for glycolic acid is 2-hydoxyethanoic acid.
Draw the structural formula for its conjugate base, showing **all** the atoms and bonds.

[1 mark]

Question 4c

c) Write an equation for the reaction between glycolic acid, $C_2H_4O_3$, and limescale, $CaCO_3$. State and explain one observation you would make.

[2 marks]

Question 4d

d) State one reason why you would use glycolic acid to remove the limescale in a kettle at home, but not hydrochloric acid.

[1 mark]

Question 5a

a) An alkaline solution is formed when sodium hydrogencarbonate is dissolved in water. Write an equation for the reaction and explain why the solution is alkaline.

[2 marks]

Question 5b

b) State whether the HCO_3^- ion is behaving as a Brønsted–Lowry acid or as a base and give a reason for your answer.

[2 marks]

Question 5c

c) Carbon dioxide gas dissolves in rainwater to form carbonic acid. State the formula of the conjugate base of carbonic acid.

[1 mark]

Question 5d

d) Carbonic acid and sulfuric acid can be described as *diprotic* acids. Explain the meaning of *diprotic.*

[1 mark]