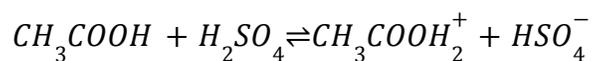


Topic 18.1 Lewis Acids & Bases

Past Exam Questions (Paper 1, 2)

1. [1 mark]

According to the Brønsted-Lowry theory, how does each species act in the equilibrium below?



	CH_3COOH	H_2SO_4	$\text{CH}_3\text{COOH}_2^+$	HSO_4^-
A.	acid	base	base	acid
B.	acid	base	acid	base
C.	base	acid	base	acid
D.	base	acid	acid	base

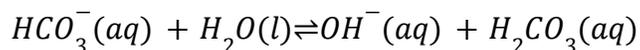
2. [1 mark]

Which reaction represents an acid-base reaction according to the Lewis theory but not according to the Brønsted-Lowry theory?

- A. $\text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\text{l}) + \text{HCO}_3^-(\text{aq})$
- B. $\text{CH}_3\text{COOH}(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq})$
- C. $\text{NH}_3(\text{aq}) + \text{HF}(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{F}^-(\text{aq})$
- D. $\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$

3. [1 mark]

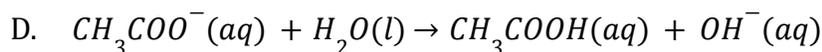
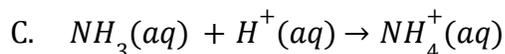
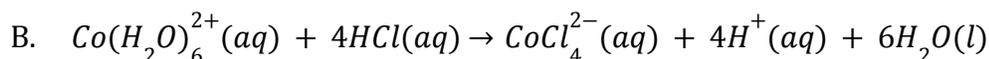
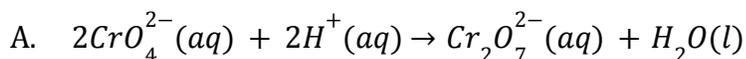
What are the conjugate acid–base pairs in the following reaction?



	Brønsted–Lowry acid	Brønsted–Lowry base	Conjugate acid	Conjugate base
A.	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$
B.	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$
C.	$\text{H}_2\text{O}(\text{l})$	$\text{HCO}_3^-(\text{aq})$	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{OH}^-(\text{aq})$
D.	$\text{H}_2\text{O}(\text{l})$	$\text{HCO}_3^-(\text{aq})$	$\text{OH}^-(\text{aq})$	$\text{H}_2\text{CO}_3(\text{aq})$

4. [1 mark]

Which of the following is an example of a Lewis acid–base reaction, but not a Brønsted–Lowry acid–base reaction?



5. [1 mark]

Which definition of a base is correct?

A. A Lewis base accepts a proton.

B. A Brønsted–Lowry base accepts an electron pair.

C. A Brønsted–Lowry base donates an electron pair.

D. A Lewis base donates an electron pair.

6. [1 mark]

Cobalt forms the complex $[Co(NH_3)_5Cl]^{2+}$. Which statements are correct for this complex?

- I. The cobalt ion acts as a Lewis acid.
 - II. The cobalt ion has an oxidation number of +II.
 - III. There are 90° bond angles between the cobalt ion and the ligands.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

7. [1 mark]

In which reaction does H_2O act as a Lewis base but not as a Brønsted–Lowry base.

- A. $H_2O + NH_4^+ \rightarrow H_3O^+ + NH_3$
- B. $H_2O + CaO \rightarrow Ca^{2+} + 2OH^-$
- C. $H_2O + [Fe(H_2O)_6]^{3+} \rightarrow Fe[(OH)(H_2O)_5]^{2+} + H_3O^+$
- D. $6H_2O + [Ni(NH_3)_6]^{2+} \rightarrow 6NH_3 + [Ni(H_2O)_6]^{2+}$

8. [1 mark]

What is the conjugate base of phenol, C_6H_5OH ?

- A. $C_6H_4^-OH$
- B. $C_6H_5-O^+H_2$
- C. $C_6H_5-O^-$
- D. $C_6H_6^+-OH$

9. [1 mark]

An equal amount of each of the following salts is added separately to the same volume of water.

Which salt will have the greatest effect on the pH of water?

- A. $Al(NO_3)_3$
- B. Na_2SO_4
- C. RbCl
- D. KBr

10. [1 mark]

Which statements are correct about the complex $[Cu(NH_3)_2Cl_2]$?

- I. Oxidation state of copper is +2.
 - II. Ammonia is a ligand.
 - III. Chloride ions act as Lewis acids.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

11. [1 mark]

Which compound forms an acidic solution when dissolved in water?

- A. $FeCl_3$
- B. CH_3NH_2
- C. $NaNO_3$
- D. Na_2CO_3

12. [1 mark]

Which are definitions of an acid according to the Brønsted-Lowry and Lewis theories?

	Brønsted-Lowry theory	Lewis theory
A.	proton donor	electron pair acceptor
B.	proton acceptor	electron pair acceptor
C.	proton acceptor	electron pair donor
D.	proton donor	electron pair donor

13. [1 mark]

Which descriptions are correct for both a Brønsted-Lowry acid and a Lewis acid?

	Brønsted-Lowry acid	Lewis acid
A.	proton donor	electron pair donor
B.	proton donor	electron pair acceptor
C.	proton acceptor	electron pair donor
D.	proton acceptor	electron pair acceptor

14. [1 mark]

Which substance can act as a Lewis acid but not as a Brønsted-Lowry acid?

- A. HCl
- B. CH₃COOH
- C. BF₃
- D. CF₃COOH

15. [1 mark]

Which definition of a base is correct?

- A. A Lewis base accepts a proton.
- B. A Brønsted-Lowry base accepts an electron pair.
- C. A Brønsted-Lowry base donates an electron pair.
- D. A Lewis base donates an electron pair.

16. [1 mark]

Which statement explains why ammonia, NH_3 , is classified as a Lewis base?

- A. It can accept a proton.
- B. It can accept a lone pair of electrons.
- C. It can donate a lone pair of electrons.
- D. It can donate a proton.

17. [1 mark]

Which species **cannot** function as a Lewis acid?

- A. BF_3
- B. $AlCl_3$
- C. CCl_4
- D. H^+

18. [1 mark]

Ammonia, NH_3 , is a weak base. It has a pK_b value of 4.75.

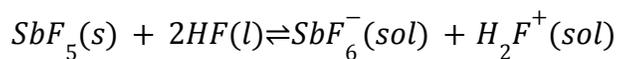
Another weak base is nitrogen trifluoride, NF_3 . Explain how NF_3 is able to function as a Lewis base.

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19a. [2 marks]

Antimony, Sb, forms a fluoride, SbF_5 .

The equilibrium that occurs when antimony(V) fluoride is dissolved in liquid hydrogen fluoride can be represented by the equation below.



Describe the relationship between SbF_5 and SbF_6^- in terms of the Lewis theory of acids.

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19b. [2 marks]

Explain the behaviour of HF in terms of the Brønsted–Lowry theory of acids.

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19c. [1 mark]

Outline how the following factors account for the fact that HCl is a strong acid and HF is a weak acid.

The strength of the hydrogen–halogen bond.

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19d. [1 mark]

The interaction between an undissociated hydrogen halide molecule and a water molecule.

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20a. [1 mark]

The element boron has two naturally occurring isotopes, ^{10}B and ^{11}B .

Phosphorus forms two chlorides, PCl_3 and PCl_5 .

Define an *acid* according to the Lewis theory.

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20b. [2 marks]

State and explain the acid–base character of PCl_3 according to the Lewis theory.

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21. [2 marks]

Acid–base chemistry can play a major role in chemical and biological processes.

White vinegar, which contains ethanoic acid, CH_3COOH , can be used as a cleaning agent to dissolve mineral deposits from coffee machines.

Define an *acid* according to the Brønsted–Lowry theory and the Lewis theory.

Brønsted–Lowry theory:

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Lewis theory:

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22a. [1 mark]

When nitrogen gas and hydrogen gas are allowed to react in a closed container the following equilibrium is established.



Define the term *base* according to the Lewis theory.

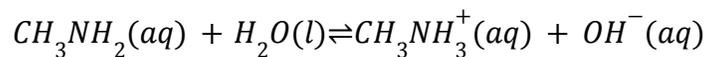
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22b. [2 marks]

Deduce the formulas of conjugate acid-base pairs in the reaction below.



Acid	Conjugate base
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