Spectroscopy & Structure Practice

INSTRUCTOR ANSWER KEY — COMPLETE EXPLANATIONS

Directions: Answers are in red. Key includes a concise rationale for each item.

1. **A strong IR absorption near 1715 cm−1 is consistent with:**

   A. C=O stretch in a simple saturated ketone

   B. C≡N stretch

   C. O–H stretch only

   D. C–H bending only

   Reasoning: Saturated acyclic ketones commonly show a strong carbonyl stretch near 1715 cm−1.

2. **A broad IR band spanning roughly 3200–3600 cm−1 often indicates:**

   A. Alcohol O–H

   B. Nitrile C≡N

   C. Alkyne C≡C only

   D. Carbonyl C=O

   Reasoning: Hydrogen-bonded alcohol O–H stretching typically produces a broad absorption in this region.

3. **A carboxylic acid O–H stretch is often characterized by:**

   A. Sharp peak at 2250 cm−1

   B. Very broad absorption about 2500–3300 cm−1

   C. Single sharp peak at 1600 cm−1

   D. No IR absorption

   Reasoning: Carboxylic acids frequently exhibit a very broad O–H envelope overlapping C–H stretching.

4. **A relatively sharp IR absorption around 2250 cm−1 can indicate:**

   A. C≡N

   B. C–O single bond

   C. Alcohol O–H

   D. Alkane C–H

   Reasoning: Nitrile C≡N stretching occurs near 2250 cm−1, although exact values vary.

5. **An aldehydic ^{1}H NMR signal commonly appears near:**

   A. 0–1 ppm

   B. 2–3 ppm

   C. 9–10 ppm

   D. 14–16 ppm

Reasoning: The proton directly bonded to a carbonyl carbon in an aldehyde is strongly deshielded.

6. An aromatic proton often resonates in approximately which ^{1}H NMR region?

A. 0–1 ppm

B. 6.5–8.5 ppm

C. 12–16 ppm

D. 18–20 ppm

Reasoning: Many aromatic C–H signals lie around 6.5–8.5 ppm, depending on substituents.

7. An ethyl fragment often shows what integration and splitting pattern in first-order ^{1}H NMR?

A. 3H triplet and 2H quartet

B. 3H singlet and 3H singlet

C. 1H septet and 6H doublet

D. 2H singlet and 2H singlet

Reasoning: An isolated CH3–CH2– unit frequently gives a methyl triplet and a methylene quartet.

8. A 6H doublet plus 1H septet can support which fragment?

A. Methoxy group

B. Isopropyl group

C. Ethene

D. Aldehyde

Reasoning: Two equivalent methyl groups coupled to one methine proton commonly show 6H doublet + 1H septet.

9. A TLC spot travels 2.4 cm while the solvent front travels 6.0 cm. Rf = ?

A. 0.25

B. 0.40

C. 2.5

D. 3.6

Reasoning: Rf = spot travel / solvent-front travel = 2.4 / 6.0 = 0.40.

10. In simple acetone, the two methyl groups give what expected ^{1}H NMR pattern?

A. Two 3H doublets

B. One 6H singlet

C. One 3H triplet

D. One 1H aldehyde singlet

Reasoning: The two equivalent methyl groups next to the carbonyl have no vicinal hydrogen splitting and give one 6H singlet.

11. A curved arrow in an organic mechanism starts at:

A. The electron source

B. The atom receiving electrons only

C. The positive charge always

D. The reaction arrow

Reasoning: The tail of a curved arrow points to the electron pair (bond or lone pair) being moved.

12. Lower pKa generally indicates:

A. Stronger acid

B. Weaker acid

C. Stronger base only

D. No connection to acidity

Reasoning: For comparable conditions, lower pKa corresponds to larger Ka and stronger acidity.

13. Which is a Lewis base?

A. Electron-pair donor

B. Electron-pair acceptor

C. Only a proton donor

D. A compound with no electrons

Reasoning: A Lewis base donates an electron pair to form a bond.

14. What is the degree of unsaturation for C6H12O (neutral closed-shell)?

A. 0

B. 1

C. 2

D. 3

Reasoning: DBE = (2C + 2 − H)/2 = (12 + 2 − 12)/2 = 1; oxygen is ignored.

15. What is the degree of unsaturation for C6H6?

A. 2

B. 3

C. 4

D. 5

Reasoning: DBE = (2×6 + 2 − 6)/2 = 4.