Oxidation Numbers Worksheet

Oxidation numbers, redox & agents • 15 parts • 150 questions • Answers at the back

Name: _____ Class: _____ Date: _____

Rules for assigning oxidation numbers

1	**Free elements**	An uncombined element is 0: Na, Fe, O_2, Cl_2, P_4, S_8.
2	**Monatomic ions**	Equal to the charge: Na^+ = +1, Mg^{2+} = +2, Cl^- = –1.
3	**Fluorine**	Always –1 in compounds.
4	**Group 1, Group 2, Al**	Group 1 metals are +1, Group 2 metals are +2, Al is +3.
5	**Hydrogen**	+1 with non-metals; –1 in metal hydrides (NaH, CaH_2).
6	**Oxygen**	–2 usually; –1 in peroxides (H_2O_2); –½ in superoxides (KO_2); positive with F (OF_2 = +2).
7	**Halogens**	Cl, Br, I are –1 unless bonded to O or F.
8	**The total**	The sum is 0 in a neutral compound and equals the charge in an ion.

OIL RIG Oxidation Is Loss of electrons Reduction Is Gain of electrons	**Example:** Mn in $KMnO_4$ (+1) + x + 4(–2) = 0 → **x = +7**	**Oxidation number goes** UP = oxidised DOWN = reduced

What's inside

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Part 1: Free Elements and Monatomic Ions

Score: _____ / 10

An uncombined element is always 0. A simple ion has an oxidation number equal to its charge.

1. Find the oxidation number of **Na** in Na.

Answer: _____

2. Find the oxidation number of **O** in O_2.

Answer: _____

3. Find the oxidation number of **P** in P_4.

Answer: _____

4. Find the oxidation number of **S** in S_8.

Answer: _____

5. Find the oxidation number of **Fe** in Fe.

Answer: _____

6. Find the oxidation number of **Cl** in Cl^-.

Answer: _____

7. Find the oxidation number of **Mg** in Mg^{2+}.

Answer: _____

8. Find the oxidation number of **Al** in Al^{3+}.

Answer: _____

9. Find the oxidation number of **S** in S^{2-}.

Answer: _____

10. Find the oxidation number of **O** in O_3.

Answer: _____

Part 2: Simple Binary Compounds

Score: _____ / 10

Give the oxidation number of each element. In a neutral compound they add up to 0.

11. Assign an oxidation number to every element in NaCl.

Answer: _____

12. Assign an oxidation number to every element in MgO.

Answer: _____

13. Assign an oxidation number to every element in K_2S.

Answer: _____

14. Assign an oxidation number to every element in CaF_2.

Answer: _____

15. Assign an oxidation number to every element in Al_2O_3.

Answer: _____

16. Assign an oxidation number to every element in H_2O.

Answer: _____

17. Assign an oxidation number to every element in NH_3.

Answer: _____

18. Assign an oxidation number to every element in CO_2.

Answer: _____

19. Assign an oxidation number to every element in Li_3N.

Answer: _____

20. Assign an oxidation number to every element in $AlCl_3$.

Answer: _____

Part 3: Oxides

Score: _____ / 10

Oxygen is usually –2. Use it to find the other element.

21. Find the oxidation number of **C** in CO_2.

Answer: _____

22. Find the oxidation number of **C** in CO.

Answer: _____

23. Find the oxidation number of **S** in SO_2.

Answer: _____

24. Find the oxidation number of **S** in SO_3.

Answer: _____

25. Find the oxidation number of **N** in N_2O_5.

Answer: _____

26. Find the oxidation number of **N** in NO_2.

Answer: _____

27. Find the oxidation number of **N** in N_2O.

Answer: _____

28. Find the oxidation number of **P** in P_4O_{10}.

Answer: _____

29. Find the oxidation number of **Cl** in Cl_2O_7.

Answer: _____

30. Find the oxidation number of **Mn** in Mn_2O_7.

Answer: _____

Part 4: Hydrogen Compounds and Metal Hydrides

Score: _____ / 10

Hydrogen is +1 with non-metals but –1 in metal hydrides such as NaH.

31. Find the oxidation number of **N** in NH_3.

Answer: _____

32. Find the oxidation number of **S** in H_2S.

Answer: _____

33. Find the oxidation number of **C** in CH_4.

Answer: _____

34. Find the oxidation number of **P** in PH_3.

Answer: _____

35. Find the oxidation number of **Cl** in HCl.

Answer: _____

36. Find the oxidation number of **H** in NaH.

Answer: _____

37. Find the oxidation number of **H** in CaH_2.

Answer: _____

38. Find the oxidation number of **H** in $LiAlH_4$.

Answer: _____

39. Find the oxidation number of **N** in N_2H_4.

Answer: _____

40. Find the oxidation number of **C** in HCN.

Answer: _____

Part 5: Polyatomic Ions

Score: _____ / 10

In an ion, the oxidation numbers add up to the charge of the ion.

41. Find the oxidation number of **S** in SO_4^{2-}.

Answer: _____

42. Find the oxidation number of **N** in NO_3^{-}.

Answer: _____

43. Find the oxidation number of **P** in PO_4^{3-}.

Answer: _____

44. Find the oxidation number of **Mn** in MnO_4^{-}.

Answer: _____

45. Find the oxidation number of **Cr** in $Cr_2O_7^{2-}$.

Answer: _____

46. Find the oxidation number of **Cl** in ClO_4^{-}.

Answer: _____

47. Find the oxidation number of **Cl** in ClO^{-}.

Answer: _____

48. Find the oxidation number of **N** in NH_4^{+}.

Answer: _____

49. Find the oxidation number of **C** in CO_3^{2-}.

Answer: _____

50. Find the oxidation number of **S** in $S_2O_3^{2-}$.

Answer: _____

Part 6: Oxyacids

Score: _____ / 10

H = +1 and O = –2. The total is 0 because acids are neutral molecules.

51. Find the oxidation number of **N** in HNO_3.

Answer: _____

52. Find the oxidation number of **N** in HNO_2.

Answer: _____

53. Find the oxidation number of **S** in H_2SO_4.

Answer: _____

54. Find the oxidation number of **S** in H_2SO_3.

Answer: _____

55. Find the oxidation number of **P** in H_3PO_4.

Answer: _____

56. Find the oxidation number of **P** in H_3PO_3.

Answer: _____

57. Find the oxidation number of **Cl** in HClO.

Answer: _____

58. Find the oxidation number of **Cl** in $HClO_2$.

Answer: _____

59. Find the oxidation number of **Cl** in $HClO_3$.

Answer: _____

60. Find the oxidation number of **Cl** in $HClO_4$.

Answer: _____

Part 7: Salts with Polyatomic Ions

Score: _____ / 10

Group 1 metals are +1 and Group 2 metals are +2. You can treat a known polyatomic ion as one unit.

61. Find the oxidation number of **Mn** in $KMnO_4$.

Answer: _____

62. Find the oxidation number of **Cr** in $K_2Cr_2O_7$.

Answer: _____

63. Find the oxidation number of **S** in Na_2SO_4.

Answer: _____

64. Find the oxidation number of **P** in $Ca_3(PO_4)_2$.

Answer: _____

65. Find the oxidation number of **Cl** in $NaClO_3$.

Answer: _____

66. Find the oxidation number of **Cr** in K_2CrO_4.

Answer: _____

67. Find the oxidation number of **C** in $Na_2C_2O_4$.

Answer: _____

68. Find the oxidation number of **I** in KIO_4.

Answer: _____

69. Find the oxidation number of **Fe** in $Fe_2(SO_4)_3$.

Answer: _____

70. Find the oxidation number of **Pb** in $Pb(NO_3)_2$.

Answer: _____

Part 8: Transition Metal Compounds

Score: _____ / 10

Transition metals can have several oxidation numbers. Work it out from the other elements.

71. Find the oxidation number of **Fe** in $FeCl_2$.

Answer: _____

72. Find the oxidation number of **Fe** in $FeCl_3$.

Answer: _____

73. Find the oxidation number of **Cu** in CuO.

Answer: _____

74. Find the oxidation number of **Cu** in Cu_2O.

Answer: _____

75. Find the oxidation number of **Mn** in MnO_2.

Answer: _____

76. Find the oxidation number of **V** in V_2O_5.

Answer: _____

77. Find the oxidation number of **Ti** in $TiCl_4$.

Answer: _____

78. Find the oxidation number of **Cr** in $CrCl_3$.

Answer: _____

79. Find the oxidation number of **Os** in OsO_4.

Answer: _____

80. Find the oxidation number of **Co** in $Co(NO_3)_2$.

Answer: _____

Part 9: Peroxides, Superoxides and Other Exceptions

Score: _____ / 10

O is –1 in peroxides, –½ in superoxides and positive with fluorine. F is always –1.

81. Find the oxidation number of **O** in H_2O_2.

Answer: _____

82. Find the oxidation number of **O** in Na_2O_2.

Answer: _____

83. Find the oxidation number of **O** in BaO_2.

Answer: _____

84. Find the oxidation number of **O** in KO_2.

Answer: _____

85. Find the oxidation number of **O** in OF_2.

Answer: _____

86. Find the oxidation number of **O** in O_2F_2.

Answer: _____

87. Find the oxidation number of **B** in $NaBH_4$.

Answer: _____

88. Find the oxidation number of **H** in MgH_2.

Answer: _____

89. Find the oxidation number of **Cl** in ClF_3.

Answer: _____

90. Find the oxidation number of **I** in IF_7.

Answer: _____

Part 10: Carbon in Organic Compounds

Score: _____ / 10

Use H = +1, O = –2 and Cl = –1. If a molecule has more than one C, the answer is the average.

91. Find the oxidation number of **C** in CH_4.

Answer: _____

92. Find the oxidation number of **C** in CH_3OH.

Answer: _____

93. Find the oxidation number of **C** in HCHO.

Answer: _____

94. Find the oxidation number of **C** in HCOOH.

Answer: _____

95. Find the oxidation number of **C** in CCl_4.

Answer: _____

96. Find the oxidation number of **C** in C_2H_6.

Answer: _____

97. Find the oxidation number of **C** in C_2H_4.

Answer: _____

98. Find the oxidation number of **C** in C_2H_2.

Answer: _____

99. Find the oxidation number of **C** in $C_6H_{12}O_6$.

Answer: _____

100. Find the oxidation number of **C** in C_2H_5OH.

Answer: _____

Part 11: Fractional (Average) Oxidation Numbers

Score: _____ / 10

Sometimes the answer is a fraction. This is the average over atoms that are in different oxidation states.

101. Find the oxidation number of **Fe** in Fe_3O_4.

Answer: _____

102. Find the oxidation number of **Pb** in Pb_3O_4.

Answer: _____

103. Find the oxidation number of **S** in $S_4O_6^{2-}$.

Answer: _____

104. Find the oxidation number of **N** in N_3^-.

Answer: _____

105. Find the oxidation number of **N** in HN_3.

Answer: _____

106. Find the oxidation number of **C** in C_3O_2.

Answer: _____

107. Find the oxidation number of **C** in C_3H_8.

Answer: _____

108. Find the oxidation number of **C** in C_4H_{10}.

Answer: _____

109. Find the oxidation number of **Br** in Br_3O_8.

Answer: _____

110. Find the oxidation number of **O** in KO_3.

Answer: _____

Part 12: Oxidised or Reduced?

Score: _____ / 10

For each reaction, state which element is oxidised and which is reduced, with the change in oxidation number. Oxidation = number goes up; reduction = number goes down.

111. $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

Answer: _____

112. $2\ Mg + O_2 \rightarrow 2\ MgO$

Answer: _____

113. $Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$

Answer: _____

114. $Cl_2 + 2\ KBr \rightarrow 2\ KCl + Br_2$

Answer: _____

115. $2\ H_2 + O_2 \rightarrow 2\ H_2O$

Answer: _____

116. $CuO + H_2 \rightarrow Cu + H_2O$

Answer: _____

117. $2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$

Answer: _____

118. $MnO_2 + 4\ HCl \rightarrow MnCl_2 + Cl_2 + 2\ H_2O$

Answer: _____

119. $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

Answer: _____

120. $Cu + 4\ HNO_3 \rightarrow Cu(NO_3)_2 + 2\ NO_2 + 2\ H_2O$

Answer: _____

Part 13: Redox or Not?

Score: _____ / 10

Decide whether each reaction is redox or not. Explain using oxidation numbers: a reaction is redox only if at least one element changes its oxidation number.

121. $NaOH + HCl \rightarrow NaCl + H_2O$

Answer: _____

122. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

Answer: _____

123. $CaCO_3 \rightarrow CaO + CO_2$

Answer: _____

124. $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

Answer: _____

125. $Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

Answer: _____

126. $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2\ NaCl$

Answer: _____

127. $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$

Answer: _____

128. $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Answer: _____

129. $SO_3 + H_2O \rightarrow H_2SO_4$

Answer: _____

130. $Cl_2 + 2\ NaOH \rightarrow NaCl + NaClO + H_2O$

Answer: _____

Part 14: Oxidising and Reducing Agents

Score: _____ / 10

Identify the oxidising agent and the reducing agent in each reaction. The oxidising agent is the reactant that is reduced; the reducing agent is the reactant that is oxidised.

131. $2\ Fe^{3+} + Sn^{2+} \rightarrow 2\ Fe^{2+} + Sn^{4+}$

Answer: _____

132. $Cu + 2\ Ag^{+} \rightarrow Cu^{2+} + 2\ Ag$

Answer: _____

133. $2\ KI + Cl_2 \rightarrow 2\ KCl + I_2$

Answer: _____

134. $H_2S + Cl_2 \rightarrow S + 2\ HCl$

Answer: _____

135. $2\ Al + Fe_2O_3 \rightarrow Al_2O_3 + 2\ Fe$

Answer: _____

136. $SO_2 + 2\ H_2S \rightarrow 3\ S + 2\ H_2O$

Answer: _____

137. $MnO_4^{-} + 5\ Fe^{2+} + 8\ H^{+} \rightarrow Mn^{2+} + 5\ Fe^{3+} + 4\ H_2O$

Answer: _____

138. $Cr_2O_7^{2-} + 6\ I^{-} + 14\ H^{+} \rightarrow 2\ Cr^{3+} + 3\ I_2 + 7\ H_2O$

Answer: _____

139. $2\ NO + O_2 \rightarrow 2\ NO_2$

Answer: _____

140. $2\ CuO + C \rightarrow 2\ Cu + CO_2$

Answer: _____

Part 15: Complex Ions and Coordination Compounds

Score: _____ / 10

Neutral ligands (NH_3, H_2O, CO) count as 0. CN^-, Cl^- and F^- count as –1.

141. Find the oxidation number of **Fe** in $[Fe(CN)_6]^{4-}$.

Answer: _____

142. Find the oxidation number of **Cu** in $[Cu(NH_3)_4]^{2+}$.

Answer: _____

143. Find the oxidation number of **Co** in $[Co(NH_3)_6]^{3+}$.

Answer: _____

144. Find the oxidation number of **Fe** in $K_4[Fe(CN)_6]$.

Answer: _____

145. Find the oxidation number of **Fe** in $K_3[Fe(CN)_6]$.

Answer: _____

146. Find the oxidation number of **Cr** in $[Cr(H_2O)_6]^{3+}$.

Answer: _____

147. Find the oxidation number of **Al** in $Na_3[AlF_6]$.

Answer: _____

148. Find the oxidation number of **Pt** in $[PtCl_6]^{2-}$.

Answer: _____

149. Find the oxidation number of **Ni** in $[Ni(CO)_4]$.

Answer: _____

150. Find the oxidation number of **Co** in $[Co(NH_3)_5Cl]Cl_2$.

Answer: _____

Answer Key

Final answers in green, with working.

Part 1: Free Elements and Monatomic Ions

1. free (uncombined) element → **Na = 0**
2. free (uncombined) element → **O = 0**
3. free (uncombined) element → **P = 0**
4. free (uncombined) element → **S = 0**
5. free (uncombined) element → **Fe = 0**
6. monatomic ion: oxidation number = charge → **Cl = –1**
7. monatomic ion: oxidation number = charge → **Mg = +2**
8. monatomic ion: oxidation number = charge → **Al = +3**
9. monatomic ion: oxidation number = charge → **S = –2**
10. free (uncombined) element → **O = 0**

Part 2: Simple Binary Compounds

11. **Na = +1**, **Cl = –1**; sum = 0
12. **Mg = +2**, **O = –2**; sum = 0
13. **K = +1**, **S = –2**; sum = 0
14. **Ca = +2**, **F = –1**; sum = 0
15. **Al = +3**, **O = –2**; sum = 0
16. **H = +1**, **O = –2**; sum = 0
17. **N = –3**, **H = +1**; sum = 0
18. **C = +4**, **O = –2**; sum = 0
19. **Li = +1**, **N = –3**; sum = 0
20. **Al = +3**, **Cl = –1**; sum = 0

Part 3: Oxides

21. O = –2: x + 2(–2) = 0 → **C = +4**
22. O = –2: x + (–2) = 0 → **C = +2**
23. O = –2: x + 2(–2) = 0 → **S = +4**
24. O = –2: x + 3(–2) = 0 → **S = +6**
25. O = –2: 2x + 5(–2) = 0 → **N = +5**
26. O = –2: x + 2(–2) = 0 → **N = +4**
27. O = –2: 2x + (–2) = 0 → **N = +1**
28. O = –2: 4x + 10(–2) = 0 → **P = +5**
29. O = –2: 2x + 7(–2) = 0 → **Cl = +7**
30. O = –2: 2x + 7(–2) = 0 → **Mn = +7**

Part 4: Hydrogen Compounds and Metal Hydrides

31. H = +1: x + 3(+1) = 0 → **N = –3**

32. H = +1: 2(+1) + x = 0 → **S = –2**

33. H = +1: x + 4(+1) = 0 → **C = –4**

34. H = +1: x + 3(+1) = 0 → **P = –3**

35. H = +1: (+1) + x = 0 → **Cl = –1**

36. Na = +1: (+1) + x = 0 → **H = –1**

37. Ca = +2: (+2) + 2x = 0 → **H = –1**

38. Li = +1, Al = +3: (+1) + (+3) + 4x = 0 → **H = –1**

39. H = +1: 2x + 4(+1) = 0 → **N = –2**

40. H = +1, N = –3: (+1) + x + (–3) = 0 → **C = +2**

Part 5: Polyatomic Ions

41. O = –2: x + 4(–2) = –2 → **S = +6**

42. O = –2: x + 3(–2) = –1 → **N = +5**

43. O = –2: x + 4(–2) = –3 → **P = +5**

44. O = –2: x + 4(–2) = –1 → **Mn = +7**

45. O = –2: 2x + 7(–2) = –2 → **Cr = +6**

46. O = –2: x + 4(–2) = –1 → **Cl = +7**

47. O = –2: x + (–2) = –1 → **Cl = +1**

48. H = +1: x + 4(+1) = +1 → **N = –3**

49. O = –2: x + 3(–2) = –2 → **C = +4**

50. O = –2: 2x + 3(–2) = –2 → **S = +2**

Part 6: Oxyacids

51. H = +1, O = –2: (+1) + x + 3(–2) = 0 → **N = +5**

52. H = +1, O = –2: (+1) + x + 2(–2) = 0 → **N = +3**

53. H = +1, O = –2: 2(+1) + x + 4(–2) = 0 → **S = +6**

54. H = +1, O = –2: 2(+1) + x + 3(–2) = 0 → **S = +4**

55. H = +1, O = –2: 3(+1) + x + 4(–2) = 0 → **P = +5**

56. H = +1, O = –2: 3(+1) + x + 3(–2) = 0 → **P = +3**

57. H = +1, O = –2: (+1) + x + (–2) = 0 → **Cl = +1**

58. H = +1, O = –2: (+1) + x + 2(–2) = 0 → **Cl = +3**

59. H = +1, O = –2: (+1) + x + 3(–2) = 0 → **Cl = +5**

60. H = +1, O = –2: (+1) + x + 4(–2) = 0 → **Cl = +7**

Part 7: Salts with Polyatomic Ions

61. K = +1, O = –2: (+1) + x + 4(–2) = 0 → **Mn = +7**

62. K = +1, O = –2: 2(+1) + 2x + 7(–2) = 0 → **Cr = +6**

63. Na = +1, O = –2: 2(+1) + x + 4(–2) = 0 → **S = +6**

64. Ca = +2, so each PO_4 is 3–: x + 4(–2) = –3 → **P = +5**

65. Na = +1, O = –2: (+1) + x + 3(–2) = 0 → **Cl = +5**

66. K = +1, O = –2: 2(+1) + x + 4(–2) = 0 → **Cr = +6**

67. Na = +1, O = –2: 2(+1) + 2x + 4(–2) = 0 → **C = +3**

68. K = +1, O = –2: (+1) + x + 4(–2) = 0 → **I = +7**

69. SO_4 is 2–: 2x + 3(–2) = 0 → **Fe = +3**

70. NO_3 is 1–: x + 2(–1) = 0 → **Pb = +2**

Part 8: Transition Metal Compounds

71. Cl = –1: x + 2(–1) = 0 → **Fe = +2**

72. Cl = –1: x + 3(–1) = 0 → **Fe = +3**

73. O = –2: x + (–2) = 0 → **Cu = +2**

74. O = –2: 2x + (–2) = 0 → **Cu = +1**

75. O = –2: x + 2(–2) = 0 → **Mn = +4**

76. O = –2: 2x + 5(–2) = 0 → **V = +5**

77. Cl = –1: x + 4(–1) = 0 → **Ti = +4**

78. Cl = –1: x + 3(–1) = 0 → **Cr = +3**

79. O = –2: x + 4(–2) = 0 → **Os = +8**

80. NO_3 is 1–: x + 2(–1) = 0 → **Co = +2**

Part 9: Peroxides, Superoxides and Other Exceptions

81. H = +1: 2(+1) + 2x = 0 → **O = –1** (peroxide)

82. Na = +1: 2(+1) + 2x = 0 → **O = –1** (peroxide)

83. Ba = +2: (+2) + 2x = 0 → **O = –1** (peroxide)

84. K = +1: (+1) + 2x = 0 → **O = –1/2** (superoxide)

85. F = –1: x + 2(–1) = 0 → **O = +2** (F is always –1)

86. F = –1: 2x + 2(–1) = 0 → **O = +1**

87. Na = +1, H = –1: (+1) + x + 4(–1) = 0 → **B = +3** (H is –1 here)

88. Mg = +2: (+2) + 2x = 0 → **H = –1** (metal hydride)

89. F = –1: x + 3(–1) = 0 → **Cl = +3**

90. F = –1: x + 7(–1) = 0 → **I = +7**

Part 10: Carbon in Organic Compounds

91. H = +1: x + 4(+1) = 0 → **C = –4**

92. H = +1, O = –2: x + 4(+1) + (–2) = 0 → **C = –2**

93. H = +1, O = –2: 2(+1) + x + (–2) = 0 → **C = 0**

94. H = +1, O = –2: 2(+1) + x + 2(–2) = 0 → **C = +2**

95. Cl = –1: x + 4(–1) = 0 → **C = +4**

96. H = +1: 2x + 6(+1) = 0 → **C = –3**

97. H = +1: 2x + 4(+1) = 0 → **C = –2**

98. H = +1: 2x + 2(+1) = 0 → **C = –1**

99. H = +1, O = –2: 6x + 12(+1) + 6(–2) = 0 → **C = 0** (average)

100. H = +1, O = –2: 2x + 6(+1) + (–2) = 0 → **C = –2** (average)

Part 11: Fractional (Average) Oxidation Numbers

101. O = –2: 3x + 4(–2) = 0 → **Fe = +8/3** (mix of Fe^{2+} and Fe^{3+})

102. O = –2: 3x + 4(–2) = 0 → **Pb = +8/3**

103. O = –2: 4x + 6(–2) = –2 → **S = +5/2**

104. : 3x = –1 → **N = –1/3** (azide ion)

105. H = +1: (+1) + 3x = 0 → **N = –1/3**

106. O = –2: 3x + 2(–2) = 0 → **C = +4/3**

107. H = +1: 3x + 8(+1) = 0 → **C = –8/3**

108. H = +1: 4x + 10(+1) = 0 → **C = –5/2**

109. O = –2: 3x + 8(–2) = 0 → **Br = +16/3**

110. K = +1: (+1) + 3x = 0 → **O = –1/3** (ozonide)

Part 12: Oxidised or Reduced?

111. Oxidised: **Zn (0 → +2)**; reduced: **Cu (+2 → 0)**

112. Oxidised: **Mg (0 → +2)**; reduced: **O (0 → –2)**

113. Oxidised: **C (+2 → +4)**; reduced: **Fe (+3 → 0)**

114. Oxidised: **Br (–1 → 0)**; reduced: **Cl (0 → –1)**

115. Oxidised: **H (0 → +1)**; reduced: **O (0 → –2)**

116. Oxidised: **H (0 → +1)**; reduced: **Cu (+2 → 0)**

117. Oxidised: **Al (0 → +3)**; reduced: **Cl (0 → –1)**

118. Oxidised: **Cl (–1 → 0)**; reduced: **Mn (+4 → +2)**

119. Oxidised: **Na (0 → +1)**; reduced: **H (+1 → 0)**

120. Oxidised: **Cu (0 → +2)**; reduced: **N (+5 → +4)**

Part 13: Redox or Not?

121. **Not redox**: no oxidation numbers change

122. **Not redox**: no oxidation numbers change

123. **Not redox**: no oxidation numbers change

124. **Redox**: oxidised O (–2 → 0); reduced Cl (+5 → –1)

125. **Redox**: oxidised Zn (0 → +2); reduced H (+1 → 0)

126. **Not redox**: no oxidation numbers change

127. **Redox**: oxidised O (–1 → 0); reduced O (–1 → –2) (disproportionation: the same element is oxidised and reduced)

128. **Redox**: oxidised C (–4 → +4); reduced O (0 → –2)

129. **Not redox**: no oxidation numbers change

130. **Redox**: oxidised Cl (0 → +1); reduced Cl (0 → –1) (disproportionation: the same element is oxidised and reduced)

Part 14: Oxidising and Reducing Agents

131. Fe (+3 → +2) reduced, Sn (+2 → +4) oxidised → oxidising agent **Fe^{3+}**; reducing agent **Sn^{2+}**

132. Ag (+1 → 0) reduced, Cu (0 → +2) oxidised → oxidising agent **Ag^{+}**; reducing agent **Cu**

133. Cl (0 → –1) reduced, I (–1 → 0) oxidised → oxidising agent **Cl_2**; reducing agent **KI**

134. Cl (0 → –1) reduced, S (–2 → 0) oxidised → oxidising agent **Cl_2**; reducing agent **H_2S**

135. Fe (+3 → 0) reduced, Al (0 → +3) oxidised → oxidising agent **Fe_2O_3**; reducing agent **Al**

136. S (+4 → 0) reduced, S (–2 → 0) oxidised → oxidising agent **SO_2**; reducing agent **H_2S**

137. Mn (+7 → +2) reduced, Fe (+2 → +3) oxidised → oxidising agent **MnO_4^-**; reducing agent **Fe^{2+}**

138. Cr (+6 → +3) reduced, I (–1 → 0) oxidised → oxidising agent **$Cr_2O_7^{2-}$**; reducing agent **I^-**

139. O (0 → –2) reduced, N (+2 → +4) oxidised → oxidising agent **O_2**; reducing agent **NO**

140. Cu (+2 → 0) reduced, C (0 → +4) oxidised → oxidising agent **CuO**; reducing agent **C**

Part 15: Complex Ions and Coordination Compounds

141. CN = –1: x + 6(–1) = –4 → **Fe = +2**

142. NH_3 = 0: x + 4(0) = +2 → **Cu = +2**

143. NH_3 = 0: x + 6(0) = +3 → **Co = +3**

144. K = +1, CN = –1: x + 4(+1) + 6(–1) = 0 → **Fe = +2**

145. K = +1, CN = –1: x + 3(+1) + 6(–1) = 0 → **Fe = +3**

146. H_2O = 0: x + 6(0) = +3 → **Cr = +3**

147. Na = +1, F = –1: x + 3(+1) + 6(–1) = 0 → **Al = +3**

148. Cl = –1: x + 6(–1) = –2 → **Pt = +4**

149. CO = 0: x + 4(0) = 0 → **Ni = 0**

150. NH_3 = 0, Cl (ligand) = –1, Cl (outside) = –1: x + 5(0) + 1(–1) + 2(–1) = 0 → **Co = +3**

Notes: 15 Key Points to Remember

01	**What an oxidation number is** It is the charge an atom would have if all its bonds were fully ionic. It is a bookkeeping tool for tracking electrons.
02	**Write the sign first** Write oxidation numbers as +2 or –3, with the sign before the number. Ion charges are written the other way: 2+, 3–.
03	**Free elements are zero** Every atom in an uncombined element is 0, even in molecules such as O_2, P_4 and S_8.
04	**Use the fixed rules first** Start with F, Group 1, Group 2, Al, H and O. Then solve for the element you do not know.
05	**Set up an equation** Multiply each oxidation number by the number of atoms and add. Set the total equal to 0 or the ion's charge, then solve for x.
06	**Watch the exceptions** H is –1 in metal hydrides. O is –1 in peroxides, –½ in superoxides and positive when bonded to fluorine.
07	**Transition metals vary** Fe can be +2 or +3, Mn can be +2 to +7. Roman numerals in names show it: iron(III) chloride is $FeCl_3$.
08	**Polyatomic ions as units** If you know the ion, use its charge: SO_4^{2-}, NO_3^-, PO_4^{3-}, OH^-, NH_4^+. This saves time with brackets.
09	**Fractions are averages** A fractional answer such as +8/3 in Fe_3O_4 means atoms of that element are in different states; it is their average.
10	**Maximum oxidation number** An element's highest oxidation number usually equals its group number: S +6, N +5, Cl +7, Mn +7, Os +8.
11	**OIL RIG** Oxidation Is Loss of electrons (oxidation number goes up). Reduction Is Gain of electrons (oxidation number goes down).
12	**Redox always happens in pairs** If one element is oxidised, another must be reduced. Electrons lost must equal electrons gained.
13	**Agents are reactants** The oxidising agent is the reactant that gets reduced; the reducing agent is the reactant that gets oxidised. Name the whole species, not just the element.
14	**Not every reaction is redox** Neutralisation, precipitation and most decompositions of carbonates do not change any oxidation numbers.
15	**Disproportionation** One element can be both oxidised and reduced in the same reaction, as in $Cl_2 + 2NaOH$ or $2H_2O_2 \rightarrow 2H_2O + O_2$.