UNIT 3
SOLID DEPOSITS

1. Heat is a form of energy.

   Heating a fluid is the same as adding ____________ to the fluid.

2. Cooling a fluid is the same as taking ____________ from the fluid.

3. Cooling a fluid (increases/decreases) the motion of its molecules.

4. Cooling a fluid also (increases/decreases) fluid pressure.

5. Suppose you suddenly decrease the *pressure* on a fluid.

   Energy is being (added/removed).

6. The fluid gets (hotter/colder).

7. Drops in pressure (heat/cool) a fluid, and may cause it to ____________.

8. You can see how this happens by opening a bottle of pop that is very cold but not frozen.

   Opening the bottle causes a sudden drop in ____________ on the pop.

9. With the right initial temperature, ice crystals will form as soon as the bottle is opened.

   The sudden release of pressure ____________ the liquid enough to freeze it.

10. When a substance freezes, the kinds of atoms in its molecules do not change.

    Frozen water (is/is not) still H_2O.

11. The difference between a liquid and a solid is in the amount of ____________ it contains.

12. Different substances have different freezing points.

    Different hydrocarbons require (the same/different) amounts of heat to remain liquids or gases.

13. At room temperature, methane is a gas.

    Oil requires (more/less) heat than methane to become a gas.

14. In the reservoir, the heavier hydrocarbons are in the (gas/oil).

15. The lighter hydrocarbons make up the ____________ in the reservoir.

16. When reservoir gas is cooled, the (heavier/lighter) hydrocarbons in the gas will turn to liquids first.

17. And the (heavier/lighter) hydrocarbons in the oil solidify first when the oil is cooled.

18. The lighter hydrocarbons can lose more heat and still remain liquids or gases.

    This is because they *require* (more/less) heat to be liquids or gases.

19. If reservoir fluids were cooled enough *all* the liquids and gases would ____________.

20. This never happens in a well because reservoir and well-bore temperatures are always too high to solidify the (heavier/lighter) hydrocarbons.

PARAFFIN

21. Paraffins, naphthenes, and aromatics are the three groups of hydrocarbons found in oil.

    Naphthenes are the lightest hydrocarbons in the oil.

    The heaviest hydrocarbons are the ____________.

22. Waxes and resins are both (paraffins/naphthenes/aromatics).

23. Paraffins solidify (before/after) naphthenes and aromatics.

24. In their solid form, paraffins tend to (be carried along with the fluid/stick to the walls of the pipe).

25. Paraffin deposits can build up enough to ____________ the flow path completely.

26. High velocities can help *prevent* build-up of paraffin in the lines.

    Paraffin deposits are more likely to be carried along with the fluid when velocity is (higher/lower).

27. If pressure drops can be reduced, (more/less) paraffin is likely to form.

28. Chokes (increase/decrease) upstream pressure.

29. So, a choke will tend to reduce the amount of paraffin that forms (upstream/downstream) from the choke.

30. Flow through the orifice of a choke is usually at a (high/low) enough velocity to prevent paraffin from depositing out.

31. You would be more likely to find paraffin deposits (upstream/downstream) from the choke.

32. Paraffin *solvents* can be used to help prevent paraffin from forming.

    Some solvents work like antifreeze.

    They cause the paraffin to freeze at a (higher/lower) temperature.

33. So, when a solvent is used, it takes a greater pressure drop to ____________ the paraffins.

34. Or you can prevent paraffins from forming by (heating/cooling) the oil.

35. Hot oil can also be used to __________ the paraffin after it has formed.

36. To control paraffin in the well-bore and tubing, hot oil or solvents must be injected in the well under __________.

37. Paraffin does not stick tightly to some types of plastic. Tubing may be lined with __________ to prevent paraffin build-up.

38. When paraffin oils are flowing, it is difficult to prevent the formation of paraffin in the tubing.

In the tubing, paraffin deposits gradually (increase/ decrease) the tubing ID.

39. In some wells, tubing must be regularly scraped with mechanical tools to remove __________ deposits.

40. Let's review the four main ways of controlling paraffin:

__________ with tools;

circulating hot __________;

coating the tubing with __________;

injecting __________ to reduce the freezing point of the paraffins.

41. Paraffins are more likely to solidify where there are (check three):

____ pressure drops
____ naphthene oils
____ paraffin oils
____ temperatures below 50°F

HYDRATES

42. A *chemical reaction* changes the molecular structure of a substance.

Changing hydrogen (H_2) and oxygen (O) to water (H_2O) is a chemical reaction.

Breaking water down into hydrogen and oxygen is also a __________ reaction.

43. Freezing and melting do not change the molecular structure of a substance.

Freezing and melting (are/are not) chemical reactions.

44. The depositing of paraffin in a well (is/is not) a chemical reaction.

45. *Hydrates* form as a chemical reaction between hydrocarbons and water.

Hydrates contain atoms of hydrogen (H), atoms of carbon (C), and atoms of oxygen (O).

Hydrates are (a kind of hydrocarbon/a kind of water/a new chemical compound).

46. In order for hydrates to form, both hydrocarbons and ____________ must be present in the fluid.

47. Heat and pressure can cause chemical reactions.

Usually, hydrate compounds form when flow line pressures are (high/low).

48. Not all hydrocarbons react with water to form hydrates, but many of the lightest fractions do.

Hydrates are more likely to form from the (gas/oil) in the reservoir.

49. Or, hydrates are new substances that form out of ____________ and hydrocarbon ____________ under ____________.

50. When flow line pressures are high enough, hydrates flow as fluids in the well.

But the freezing point of a hydrate (at surface pressures) may be around 60°F.

When temperatures drop below 60°F, hydrates may ____________ in the line.

51. Hydrate solids in the line look like snow.

But they form at temperatures well (above/below) the freezing point of water.

52. In the line, hydrate solids act like slushy snow.

Unlike paraffin, hydrate solids usually do not ____________ to the walls of the pipe.

53. Hydrates are carried along with the fluid until they reach a ____________ in the line.

54. Then they build up, and may restrict or ____________ flow completely.

55. Hydrates are (more likely/less likely) than paraffin to plug a choke.

56. Like paraffin, hydrates solidify when there is a sudden pressure ____________ in the line.

57. Since hydrate compounds require high pressures to form, hydrates tend to occur more often in (flowing/pumping) wells.

58. And they occur only if there is some ____________ mixed with the hydrocarbons.

59. Once the hydrate compounds have formed, they can be kept in the liquid stage longer by keeping line pressures *high.*

Pressure drops (heat/cool) the fluid and may cause hydrates to solidify.

60. When chokes are used, hydrates can be kept from freezing by keeping the fluids (warm/cool) as they pass through the choke.

61. Bottom-hole chokes can be set deep in the tubing, where the earth's heat keeps the fluids warm.

To prevent hydrates from depositing at the choke, a ____________-____________ choke may be used.

62. Surface chokes may need to be ____________ to prevent hydrates from freezing at the choke.

63. Velocity of flow affects hydrate deposits more than it affects paraffins.

Hydrates are (more likely/less likely) than paraffins to be carried along with a rapid flow.

64. *Methanol* is a solvent for hydrates.

Injections of methanol may __________ hydrate solids.

65. Or, a *line heater* may be used on surface flow lines to __________ the hydrates.

66. Line heaters are more effective if they are set (near/away from) a choke.

67. Since hydrates pile up at bends or restrictions in the line, plugging can also be reduced by keeping the lines as __________ as possible.

68. The hydrocarbons can be recovered from hydrates by another chemical reaction and sold as petroleum products.

Hydrates (have/do not have) commercial value.

69. Let's review the ways hydrates are controlled:

by installing a bottom-hole __________;

by injecting __________ into the fluid;

by installing a line __________ at the surface chokes;

by keeping flow lines as __________ as possible.

SCALE

70. Pressure drops cool a liquid; they also cause some of the liquid to evaporate.

Evaporation is the changing of a liquid to a __________.

71. When dissolved gas is released from solution in the reservoir fluid, this is more like the (cooling/evaporating) effect of pressure drops.

72. At higher pressures, a liquid can absorb more heat than it can absorb at lower pressures.

A pressure cooker cooks food faster because it is cooking at a (higher/lower) temperature.

73. Or, the temperature at which a liquid will *evaporate* is (higher/lower) at higher pressures.

74. Reservoir fluids at high pressures contain (more/less) heat than fluids at lower pressures.

75. When the pressure on the fluid drops suddenly, some of this heat escapes as vapor.

    This is because the *vapor point* of the liquid is (higher/lower) at lower pressures.

76. The escape of the vapor cools the liquid.

    Paraffins and hydrates result from this ____________ effect of pressure drops.

77. Scale comes from salt compounds in the formation water.

    At higher pressures and temperatures, these salts are dissolved in the ____________.

78. Water is *saturated* with salt when it has dissolved all the salt it can carry.

    If you try to add salt to a glass of saturated water, some of the salt will ____________ at the bottom of the glass.

79. Suppose you evaporate some of a saturated liquid.

    There is (more/less) liquid to carry the salt.

80. So, some of the salt will ____________ out.

81. Some reservoirs contain fresh water, but most reservoir waters are salty.

    More scale forms when the reservoir water is (fresh/salt) water.

82. When there is more salt in the water, (more/less) scale will deposit out at pressure drops.

83. Scale is crusty and hard to remove from equipment.

    Well equipment may need to be pulled and cleaned or ____________ when scale deposits build up.

84. Some solvents can be used to ____________ scale after it has formed.

85. Scale-inhibition programs are used to ____________ the formation of scale.

REVIEW AND SUMMARY

86. Solid deposits form in flowing fluids when either the temperature or the ____________ of the fluid drops suddenly.

87. Since chokes cause pressure drops, solids often deposit (upstream/downstream) from a choke.

88. When pressure drops occur deep in the well, the earth's heat helps prevent solids from ____________ in the fluid.

89. Fewer solids will deposit out downstream from a (surface/bottom-hole) choke.

90. The deposit that forms from the salt in the reservoir water is ____________.

91. Scale may eventually block the perforations in the production casing and so reduce ____________ into the well-bore.

92. The pressure drop at the sand face may cause ____________ to deposit out of the reservoir water.

93. Paraffin deposits out of the heaviest hydrocarbons in the reservoir (gas/oil).

94. Paraffins may deposit out whenever the temperatures and pressures on the fluid go (above/below) the freezing point of paraffins.

95. Paraffins are wax-like deposits that ____________ to the walls of the pipe.

96. Paraffins may be dislodged and carried along with the fluids if the ____________ of flow in the line is high enough.

97. Usually, paraffins are melted with hot ___________, dissolved with solvents, or scraped with mechanical ___________ to remove them from the tubing.

98. Hydrates form as a chemical reaction between hydrocarbon ___________ and ___________, in the presence of high pressure.

99. Hydrates (stick/do not stick) to the tubing.

100. Hydrates pile up at ___________ in the flow path, and can easily ___________ a surface choke.

101. Hydrates can be ___________ with methanol or prevented from forming by keeping flowline temperatures ___________.

102. Since pressure drops cool a fluid, solids are less likely to form in the well-bore when tubing pressure is kept ___________.

103. Surface chokes put back ___________ on the tubing and so help (cause/prevent) the depositing of solids in the tubing.

104. The main purpose of a choke is to control the ___________ of flow from the well.

105. Control of flow helps prevent the GOR from ___________ and also helps prevent ___________ from depositing in the tubing.

106. Choking also helps prevent damage to the formation rock.

If fluid were allowed to leave the reservoir at an uncontrolled velocity, the formation and the sand face could be ___________.

107. An uncontrolled flow from the reservoir would also mean that the oil, gas, and water would be mixed together before it left the reservoir.

For optimum recovery, most of the fluid entering the well-bore should come from the layer of ___________ in the reservoir.

108. Fluid can be drawn more directly from the layer of oil when the flow ____________ is controlled.

109. Chokes can also prevent early heading, by building up ____________ ____________ upstream.

110. Back pressure can help prevent the break-out of ____________, which causes heading.

111. Choking helps conserve reservoir pressure by:

preventing the break-out of ____________;

preventing ____________ to the formation;

reducing the volume of __________ and __________ that is drawn along with the oil.

112. Choking reduces problems in the well-bore by:

inhibiting the formation of ____________ in the fluid; and by

controlling the break-out of ____________ in the well-bore.

113. Bottom-hole chokes may be used:

to release more ____________ in the well, and thus increase its lifting power;

to put pressure drops deep in the well-bore, when temperatures are ____________ enough to prevent solids from depositing out.

THE END