Name: ________________

Answer the True/False and Multiple Choice questions on the scantron sheet. Answer the remaining questions on this exam handout. Turn in both the scantron and exam at the end of class. The exam out of 75.

True/False Questions

1. (1 point) Thermohaline circulation is the process whereby surface seawater becomes denser at high latitudes and sinks to form new deep water.
   A. True  B. False

2. (1 point) The speed of light is slower in water than in air.
   A. True  B. False

3. (1 point) Temperature and salinity affect water density. Cold, salty water tends to sink.
   A. True  B. False

4. (1 point) Deep water waves transport the same water particles over the entire distance they travel.
   A. True  B. False

5. (1 point) This is a deep water wave. True or False.

   ![Direction of wave](image)

   A. True  B. False

6. (1 point) The concentration of Silicate in the deep water of the Pacific Ocean is greater than that in the deep water of the Atlantic Ocean.
   A. True  B. False

7. (1 point) A significant contributor to future global sea level rise is thermal expansion of ocean water.
   A. True  B. False

8. (1 point) Tritium ($^3$H) is a chemical that can be used to trace the physical movement of water in the oceans.
   A. True  B. False

9. (1 point) El Nino is a very recent climatic event dating from 1970.
   A. True  B. False
10. (1 point) Tides are created only as a result of gravitational attraction.
   A. True   B. False

11. (1 point) Tsunami are deep water waves.
   A. True   B. False

12. (1 point) Short residence time elements are found in the greatest concentration near their point of removal from the ocean.
   A. True   B. False

13. (1 point) Atmospheric carbon dioxide levels are currently higher than they have been during the last 400,000 years.
   A. True   B. False

14. (1 point) During El Nino the upwelling of cold water along the coast of South America ceases.
   A. True   B. False

15. (1 point) More solar radiation per m$^2$ reaches the poles than tropics.
   A. True   B. False

16. (1 point) The following statement is true or false: “regardless of how the salinity may vary from place to place the ratios between the amounts of the major ions in the waters of the open ocean are nearly constant”.
   A. True   B. False

17. (1 point) Deserts are found at the latitudes (around 30° North and South) where air masses are rising.
   A. True   B. False

18. (1 point) Surface currents are driven by thermohaline processes.
   A. True   B. False

19. (1 point) Methane is also a greenhouse gas.
   A. True   B. False

20. (1 point) During El Nino conditions hurricanes are less likely to come near Hawaii.
   A. True   B. False

Multiple Choice Questions

21. (1 point) The polarized nature of a water molecule means water
   A. is a good natural solvent
   B. is a bad solvent
   C. is a liquid
   D. has a freezing point of 0°C
22. (1 point) In the video clip with the aircraft carrier we watch in class was there (over 90% of you voted to have this question on the exam)
   A. a helicopter in the air.
   B. two helicopters in the air.
   C. a helicopter on the flight deck.
   D. no helicopter.

23. (1 point) A wave behaves as a shallow water wave when the depth of the ocean is less than
   A. one wavelength.
   B. 1/2 wavelength.
   C. 1/20 wavelength.
   D. 1/23 wavelength.

24. (1 point) Based on your knowledge of Coriolis and Ekman transport, how do you think coastal upwelling works on the west coast of the US?
   A. Southerly wind (poleward) pushes water offshore allowing deep water to surface near the coast.
   B. Northerly wind (equatorward) pushes water offshore allowing deep water to surface near the coast.
   C. Southerly wind (poleward) pulls water towards the coast.
   D. Offshore wind directly offshore.

25. (1 point) During El Nino conditions the surface waters of the eastern Pacific are:
   A. colder than normal
   B. warmer than normal
   C. more productive than normal
   D. drier than normal

26. (1 point) The most recent measurements of sea level rise from satellites show sea level rising at:
   A. 1 mm/year
   B. 3 mm/year
   C. 10 mm/year
   D. 20 mm/year

27. (1 point) If caught in a rip current you should
   A. Loose all hope and drown
   B. Wait and see if a cute lifeguard will rescue you
   C. Swim across it (parallel to shore)
   D. Swim against it (straight into shore)
28. (1 point) Photosynthesis can only occur near the surface, where there is light. Therefore biologically active nutrients will be
   A. Depleted with depth.
   B. Depleted at the surface.
   C. Unchanged with depth.

29. (1 point) Incoming solar radiation has wavelengths primarily in the ________________ portion of the electromagnetic spectrum.
   A. ultraviolet
   B. visible
   C. infrared

30. (1 point) Atmospheric CO$_2$ is
   A. important to global climate because it traps reflected shortwave solar radiation
   B. important to global climate because it absorbs and reemits longwave radiation
   C. important to global climate because it reflects longwave radiation
   D. not important to global climate

31. (1 point) How much salt is dissolved in a kilogram of typical seawater?
   A. 1 gram.
   B. 15 grams.
   C. 35 grams.
   D. 0.1 grams.

32. (1 point) Which of the following chemicals is most likely to be the limiting nutrient in the surface waters of the ocean?
   A. calcium.
   B. silicon.
   C. carbon.
   D. phosphorous.
   E. cadmium.

33. (1 point) In water the speed of sound
   A. increases with decreasing temperature.
   B. increases with increasing pressure.
   C. all of the above.
   D. none of the above.
34. (1 point) High salinity (e.g. in the Mediterranean Sea) is due to:
   A. Fish sweating.
   B. Precipitation exceeding evaporation.
   C. Evaporation exceeding precipitation.
   D. Both B & C.

35. (1 point) Which statement is true:
   A. Warm water sinks, cold water rises.
   B. Neither warm or cold water rise or sink.
   C. Both warm and cold water rise.
   D. Warm water rises, cold water sinks.
   E. Both warm and cold water sink.

36. (1 point) The thermocline is the part of the ocean where
   A. the density changes rapidly.
   B. salinity changes rapidly.
   C. the temperature changes rapidly.
   D. you are most likely to find Elvis.

37. (1 point) Why is the ocean salty?
   A. Material from volcanos.
   B. Material from hydrothermal vents.
   C. Material from rivers.
   D. All of the above.
   E. None of the above.

38. (1 point) A high pressure system in the Northern Hemisphere will have
   A. rising air which draws surface air in, the surface winds spiral to the left.
   B. rising air which draws surface air in, the surface winds spiral to the right.
   C. sinking air which pushes surface air out, the surface winds spiral to the left.
   D. sinking air which pushes surface air out, the surface winds spiral to the right.

39. (1 point) Currents flow around the gyres because of
   A. geostrophic balance.
   B. Coriolis force.
   C. trade winds.
   D. Ekman spiral.
40. (1 point) Spring tides occur when:
   A. the moon is one quarter.
   B. the Sun and Moon are aligned with the Earth.
   C. Jupiter is aligned with Mars.
   D. During April, May.
   E. None of the above

41. (1 point) If a wind wave has a period of 12 seconds it’s velocity in meters per second in deep water would be approximately:
   A. 8
   B. 12
   C. 18
   D. 24

42. (1 point) Western boundary currents are:
   A. slower than eastern boundary currents.
   B. colder than eastern boundary currents.
   C. all of the above.
   D. none of the above.

43. (1 point) The anthropogenic CO$_2$ currently ends up distributed
   A. 100% in the atmosphere
   B. 100% in the ocean
   C. 90% in the atmosphere, and 10% in ocean
   D. 90% in the atmosphere, and 10% in terrestrial biomass
   E. 50% in the atmosphere, 25% in ocean and 25% in terrestrial biomass

44. (1 point) If a shallow wave wave is propagating in 100m water depth, its speed is
   A. 10 m/s
   B. 15 m/s
   C. 20 m/s
   D. 30 m/s
   E. 150 m/s

45. (1 point) Ekman transport in the Northern Hemisphere is
   A. in the same direction as the wind over the top 100m
   B. 45° to the left of the wind, over a layer extending down to the depth where the current in the opposite direction to the wind
   C. 90° to the right of the wind, over a layer extending down to the depth where the current in the opposite direction to the wind
   D. 90° to the right of the wind over the top 100m
46. (1 point) Waves always bend (refract) toward the region or medium where they:
   A. Originated
   B. Move slowest
   C. Move fastest
   D. Can create capillary waves

47. (1 point) The composition of dry air is:
   A. 78% O$_2$, 21% N$_2$
   B. 78% N$_2$, 21% O$_2$
   C. 78% N$_2$, 21% CO$_2$
   D. mainly water vapor

48. (1 point) The average time it takes a water molecule to complete the thermohaline circulation loop (so called ocean conveyor belt) is:
   A. much less than the residence time of the major ions
   B. slightly less than the residence time of the major ions
   C. the same as the residence time of the major ions
   D. slightly greater than the residence time of the major ions
   E. much greater than the residence time of the major ions

49. (1 point) Data from ice-cores shows that when carbon dioxide levels in the atmosphere went down, average planetary temperatures:
   A. stayed the same
   B. went up
   C. went down
   D. none of the above

50. (1 point) The average speed of sound in water is:
   A. 5 m/s
   B. 500 m/s
   C. 1500 m/s
   D. 5000 m/s
   E. same as in air

**Fill in the Blanks**

51. (3 points) Three mechanisms by which heat can be transferred are: _______________________, _______________________, and _______________________.

Longer answer

52. (2 points) Why is the ocean blue?

53. (a) (1 point) On dashed line in the figure below mark the region of high pressure and low pressure with a H and L, respectively.

(b) (2 points) Draw the direction of motion without rotation: towards the left (←), towards the right (→), into the page (⨂), or out of the page (⨀).

(c) (2 points) Draw the direction of motion in the Northern Hemisphere under the geostrophic balance: towards the left (←), towards the right (→), into the page (⨂), or out of the page (⨀).
54. (3 points) List 3 (and only 3) of the 6 major ions in seawater?

55. Use the TS diagram below, and sketch lines on the TS diagram indicating your working.

(a) (2 points) What is the density to the nearest kg/m$^3$ of water with a temperature (T) of 25°C and a salinity (S) of 36 g/kg?

(b) (2 points) Is water with T = 25°C and S = 36 g/kg more or less dense than water with T = 0°C and S = 33.5 g/kg?
56. (2 points) In one sentence define a limiting nutrient.

57. (6 points) For each column (A, B, C) in the figure below answer the following two questions (i.e., 6 answers required).
   (a) Is the radiation longwave or shortwave?
   (b) Is the heat source Sun, Moon, Earth, or Atmosphere.