NTNU
Det skapende universitet

Institutt for biologi

Exam in BI3061 Biological Oceanography

Contact under exam: Geir Johnsen

Tlf.: 9189 7027

Date of exam: 13 December 2014

Duration of exam: 4 hours

Credits: 7.5

Allowed aids: none

Language: 10 pages English

41 questions (9 pages)

No enclosures

Date of censorship: 3 January 2015

Comments: Please list the answers on a separate page

Only one of the five choices should be picked from each question

Controlled by:

Date Sign

1. Salinity. What statement is true?
A. The modern definition of salinity is based on the electrical conductivity of seawater
B. The modern unit is per mil (‰)
C. Salinity is the sum of sodium and calcite ions
D. Chlorinity is the ratio between sodium and chloride ions
E. Global ocean salinity averages 33.8

2. Salinity: What does the Forchhammer principle imply? What statement is true?
A. The concentration of a single ion in seawater increases linearly with increasing salinity
B. The ratio between sodium and chloride ions is a variable in ocean water
C. The ratio between the different ions in seawater is strongly affected by pressure
D. The ratio between the different macro-ions in seawater is dependent on water temperature
E. The Forchhammer principle sums properties of sea waves

3. Hydrophysical variables. What statement is NOT true?
A. Water is incompressible, for this reason sound waves may pass through water
B. Sigma (σ) should not be used as input in equations involving seawater density
C. Salinity and temperature are the most important variables that determine density of seawater
D. The modern unit for pressure is pascal
E. Low compressibility of water is caused its high number of hydrogen bonds

4. Hydrography, etc. What statement is NOT true?
A. A halocline is an abrupt change in salinity against depth
B. A relatively abrupt change in density against depth is called a pyknocline
C. In the course of the growth season, an oxygen minimum is usually formed at medium depths
D. There is an oxygen minimum in the surface layer in summer
E. A "station curve" shows the distribution of a measurement variable against depth

5. Hydrography, etc. What statement is true?
A. A nutricline is a sharp change in salinity across a narrow depth interval
B. A sharp change in oxygen concentration across a narrow depth interval is called a halocline
C. Typical for the summer season, a nitrate maximum is established at the surface
D. An isopleth graph shows the distribution of hydrographical variables against depth and date
E. A t-S graph shows the distribution of seawater density against salinity

6. Diffusion. What statement is true?
A. Molecular diffusion is important for birds and mammals in terms of gas exchange and waste removal
B. Molecular diffusion covers a longer distance in air than in water in the same period of time
C. The units of the molecular diffusion coefficient is m^2 $m^{\square 3}$
D. A fluid with a low molecular diffusion coefficient spreads across a larger area than one with a high diffusion coefficient in the same period of time
E. The diffusion coefficient is relevant only for solid matter

7. Viscosity. What statement is true?
A. Viscosity exists only in laboratory experiments
B. Honey is less viscous than water
C. Glycerol is less viscous than water
D. Hot water is more viscous than cold water
E. Glass has the highest known viscosity

8. Reynolds numbers. What statement is true?
A. Swimming small copepods live in a viscous environment, yet when jumping, they enter an inertial environment
B. Reynolds numbers >2 indicate that viscous forces are dominating
C. Flying insects have smaller Reynolds numbers than microscopic flagellates
D. To overcome inertial forces, some micro-organisms use flagella
E. The microlayer of water surrounding a micro-organism accelerates nutrient uptake

9. What statement about Reynolds numbers is NOT true?
A. The higher the speed of swimming organisms, the higher their Reynolds numbers
B. The larger the organism, the higher its Reynolds number
C. The less viscous the surrounding fluid, the smaller the Reynolds number of an organism
D. Reynolds numbers are dimensionless
E. Large jumping copepods such as *Calanus* sp. invariably live in an inertial environment

10. What statement about fluids is true?
A. In gases, viscosity decreases with increasing temperature
B. Gases and liquids are collectively known as fluids
C. The higher the viscosity, the more turbulent the flow
D. Seawater is a non-Newtonian fluid
E. Honey, custard and tomato ketchup are Newtonian fluids

11. What statement about the sinking rate of plankton is NOT true?
A. A spherical cell sinks slower the smaller its diameter
B. Fat or gas vacuoles may help large cells stay in the surface layer
C. Silicate or calcium carbonate cover may help plankton cells stay buoyant
D. The density of naked cells typically is close to that of water
E. Stokes' law is defined for spherical cells

12. Light. What statement is NOT true?
A. Colour is imagined by the brain and is a function of energy per photon (or wavelength)
B. The speed of light is dependent on the medium through which it passes
C. Irradiance is radiation hitting a surface per unit area
D. The human eye has strongest sensitivity in red light
E. Eyes/brain of some insects can absorb/process ultraviolet light

13. What statement about light is true?
A. The sky appears blue because the atmosphere absorbs red light strongly
B. In the clearest seawater, violet light penetrates deepest
C. cDOC gives coastal waters off the Norwegian coast a blue hue
D. Oceanic seawater appears blue mainly because of Rayleigh scattering
E. Colour of the sea surface is strongly affected by the sky and its clouds

14. Light: What statement is NOT true?
A. Light is electromagnetic radiation
B. Light has two modes: Either it is a stream of particles or a train of waves
C. An experiment cannot reveal both modes perfectly at the same time
D. The refraction index is higher for air than water
E. Light hitting a transparent medium vertically is not refracted

15. Light measurements: Which statement is true?
A. Scalar irradiance ideally measures light from a certain angle
B. The energy scale overrates photosynthetic activity in red light
C. The cosine effect equals naught (zero) under zenith sun
D. The best scale for measuring photosynthetic activity is the quantum scale
E. The units for quantum-scale measurements are typically W $(mm)^{-2}$

16. What statement about light is NOT true?
A. In pure water, absorption is more important than Rayleigh scattering
B. Maximum reflection from a calm sea surface occurs at noon
C. Clouds produce mainly spectrally neutral and forward Mie scattering
D. The colour of *Emiliania huxleyi* blooms shows mainly the colour of the above-lying water
E. Calcium carbonate in coccoliths causes strong reflection back to the surface

17. Sound: What statement is true?
A. If a particle were smaller than the wavelength of sound/light, echo sounding/microscopy would not detect it
B. The speed of sound is independent of temperature
C. Sound consists of electromagnetic waves
D. Sound waves can propagate through water because water is entirely incompressible
E. Sound propagates slower through water than air

18. Plant nutrients. What statement is NOT true?
A. Nutrient concentrations are generally lower in deep than in surface waters
B. There is far less phosphate in Scandinavian (non-polluted) freshwater than in seawater
C. Apart from winter mixing, the main sources of silicate and iron 2+ are rivers
D. The ratio between the maximum uptake rate and the half-saturation coefficient for the limiting nutrient is known as ‘affinity’
E. Deep-water nutrient concentrations are generally higher in the Pacific than the North Atlantic Ocean

19. Plant nutrients. What statement is NOT true?

A. Michaelis-Menten functions express the relationship between uptake rate and the concentration of the limiting nutrient in the growth medium
B. There is usually more ammonia in surface waters in winter than during the growth season
C. Redfield ratio for N and P in nitrate and phosphate, respectively, is about 16 (mol/mol) in ocean water
D. The N:P ratio of healthy plankton is species-dependent yet usually averages 16 (mol/mol) for the whole phytoplankton community
E. In Scandinavia, low salinity in fjords increases the likelihood of P-limitation of phytoplankton growth

20. Growth rate: What statement is NOT true?

A. In the exponential growth phase, the growth rate is by definition constant
B. The very first phase of an algal culture is called the lag phase
C. The specific growth rate has the units day^{-1} and the symbol μ
D. During steady-state growth, the growth rate of a population is larger than its loss rate
E. Magnesium ions are never limiting algal growth in the sea

21. Waves. What statement is NOT true?

A. Standing waves do not propagate
B. Swells are long-waved and may reach across thousands of kilometres
C. Rogue waves are especially common along the east coast of southern Africa
D. Undertows are caused by internal waves
E. A soliton is a half wave in which both energy and water move forwards

22. Waves. What statement is true?

A. Shallow-water waves reach down to the bottom
B. Shallow-water waves exist only in shallow waters
C. Tsunamis are deep-water waves
D. Swells can cause problems in fjords
E. Internal waves arise in the boundary between the bottom and the water

23. Tides. What statement is NOT true?

A. The moon has greater impact on tides than the sun
B. Spring and ebb tides simultaneously neutralise each other
C. The east side of the Atlantic Ocean (except the Mediterranean Sea) possesses a semidiurnal tidal cycle
D. The largest tidal difference arises in bays where resonance frequency equals tidal frequency
E. Wind-induced waves have impact only in the upper 500 metres of the water column

24. Tides. What statement is true?

A. In an amphidromic system, the tidal difference is ¼ the maximum height
B. Oceans do not exhibit amphidromic points
C. Amphidromic systems rotate clockwise in the northern hemisphere
D. The North Sea possesses amphidromic points
E. Rivers possess amphidromic systems

25. What statement about ENSO is true?
A. El Niño is most likely when the Southern Oscillation (SO) index is positive
B. El Niño arises when trade winds (easterlies) are abnormally strong
C. SO index is the normalised difference in atmospheric surface pressure between Tahiti and Darwin (Australia)
D. La Niña causes droughts in Australia and Southeast Asia
E. El Niño causes particularly high primary production in the coastal waters off Peru

26. What statement about the NAO index is true?
A. Positive index implies a narrow and fast Atlantic Current
B. Positive index implies large bottom water production in the Greenland Sea
C. Positive index implies large production of sea ice along the Siberian shelf
D. NAO index was strongly positive in the 1960s
E. Negative index implies enhanced biological production in the Barents Sea

27. Why is remote sensing of ocean colour measured in the visual spectrum (400-700 nm)? What statement is correct?
A. Most of the matter that contributes to ocean colour absorbs in the 400-700 nm band
B. Detectors exist only for this wavelength band
C. It is the only wavelength band that can be seen by the human eye
D. Because only the 400-700 nm wavelengths are sufficiently energetic for detection by satellite sensors
E. To separate between night and day

28. Photosynthesis and respiration. What statement is correct?
A. Photosynthetic organisms do not perform respiration
B. Photosynthesis and respiration are two completely unrelated processes
C. Respiratory losses are defined as the rate of electron flow from organic carbon to CO_2
D. When calculating net photosynthesis and net primary production, we separate between respiration done in the light, R_L and respiration done in the dark, R_D
E. Net photosynthesis, P_N is the difference between gross photosynthesis and respiration losses both in the light and in the dark

29. Primary production. What statement is NOT correct?
A. About half of the estimated global primary production takes place in the oceans
B. The main primary producers in the world ocean are sea-grasses and macro-algae (kelp and seaweeds)
C. Macro-algae are important primary producers in coastal areas, and also important as keystone species of kelp forest habitats by offering food, shelter, substrate, etc., for other species
D. Phytoplankton can form large blooms that support other species at higher trophic levels
E. Primary production takes place even in the more extreme environments in the ocean, e.g. by ice algae underneath the ice cover in Arctic and Antarctic seas

30. Phytoplankton functional types (PFTs). What statement is correct?

A. The 7 major PFTs are defined according to their biogeochemical role, light sensitivity, behaviour, and qualitative importance in specific geographical regions

B. The 7 major PFTs are based on primary production characteristics, photosynthetic performance, pigment composition, behaviour, and qualitative importance in specific geographical regions

C. The 7 major PFTs are based on their biogeochemical role, physiological and environmental requirements, behaviour, and qualitative importance in specific geographical regions

D. The 7 major PFTs are based on their primary production characteristics, acclimation status, biomass, and harmful algae

E. The 7 major PFTs are based on their biogeochemical role, acclimation status, harmful algal blooms, and qualitative importance in specific regions

31. Limitation of *in situ* marine biological observations during the polar night? What statement is NOT true?

A. High economic expenses, darkness, wave action, ice cover and ice thickness.

B. Range limitations of research vessels (time consuming and expensive), sea ice, light conditions and cold

C. Few ice-going vessels, limited use of sensor platforms such as underwater robots

D. Cold and dark, high human health risks, little sea ice, few available ice-going vessels

E. Cold and dark, ice cover, logistical constraints, satellites that cannot "sense" biological features in the dark

32. What 4 major problems arise in connection with satellite remote sensing of phytoplankton? What statement is correct?

A. Data-storage capacity in satellite, image resolution (pixel density), re-visit time, discrimination between chlorophyll a and yellow substance (cDOM).

B. Cloud cover/light conditions, image resolution (pixel density), re-visit time, discrimination between chlorophyll a and yellow substance (cDOM).

C. Cloud cover, data storage capacity in satellite, re-visit time, image resolution (pixel density).

D. Cloud cover, image resolution (pixel density), re-visit time, data transmission

E. Cloud cover, data storage capacity, correction algorithms in air and water, discrimination between chlorophyll a and yellow substance (cDOM).

33. What is the advantage of using remote sensing to detect and map phytoplankton? What statement is correct?

A. Satellites cover large areas, provide time-series, use for operational purposes (e.g. harmful algal blooms), creates overview maps of blooms

B. Satellites cover large areas, provide time-series, can be used for operational purposes (e.g. harmful algal blooms), creates detailed maps of blooms on species level

C. Satellites cover large areas, provide details of phytoplankton species, can be used for operational purposes (e.g. harmful algal blooms), creating detailed maps of blooms at the species level

D. Satellites cover large areas, provide details of salinity, can be used for operational purposes (e.g. harmful algal blooms), creates detailed maps of blooms at the species level

E. Satellites cover large areas, provide details of phytoplankton species, can be used for operational purposes (e.g. harmful algal blooms), creating detailed maps of sediment types

34. What are the limitations using remote sensing to detect and map phytoplankton distribution in the sea? What statement is correct?

A. Satellites acquire information from sea surface down to 30 m depth, dependent on sun and cloud cover, do not discriminate between pigment groups, dependent on local algortms regarding atmospheric and water properties

B. Satellites acquire information from sea surface only, dependent on sun and cloud cover, do not discriminate between pigment groups, dependent on local algorithms in regard to atmospheric and water properties

C. Satellites acquire information from sea surface only, independent on sun and cloud cover, do not discriminate between pigment groups, dependent on local algorithms regarding atmospheric and water properties

D. Satellites acquire information from large areas, dependent on sun and cloud cover, do not discriminate between pigment groups, cannot use local algorithms regarding atmospheric and water properties

E. Satellites acquire information from sea surface only, independent on sun and cloud cover, do discriminate between pigment groups, dependent on local algorithms in regard to atmospheric and water properties

35. Inherent (IOP) and apparent (AOP) optical properties of sea water. What statement is true?

A. IOP of seawater comprise the optical properties of the water, zooplankton, tripton and total suspended matter (TSM)

B. IOP of seawater comprise the optical properties of the water, phytoplankton, coloured dissolved organic matter (cDOM) and total suspended matter (TSM)

C. IOP of seawater comprise phytoplankton, zooplankton, salinity and total suspended matter (TSM)

D. IOP of seawater comprise phytoplankton, zooplankton, salinity, total suspended matter (TSM) and cDOM

E. IOP of seawater comprise phytoplankton, cDOM, total suspended matter (TSM)

36. Colour of Norwegian coastal water. What statement is correct?

A. Norwegian coastal water is always green due to phytoplankton light absorption.

B. Norwegian coastal water is always green due to phytoplankton light absorption and scattering.

C. Norwegian coastal water is always green due to absorption by cDOM (coloured dissolved organic matter) and phytoplankton

D. Norwegian coastal water is always green due to TSM (total suspended matter).

E. Norwegian coastal water is always green due to light scattering by cDOM.

37. Case 1 versus case 2 waters. Which statement is correct?

1. Case 1 water are optically complex waters with absorption and scattering due to TSM (total suspended matter) and the water itself

B. Case 1 water is the same as Case 2 water, only that Case 1 water has higher salinity.

C. Case 1 water is “optically simple” oceanic blue waters mainly affected by IOP of water and phytoplankton.

D. Case 1 waters is ”optically complex” coastal green water affected mainly by IOP of water, phytoplankton and TSM (total suspended matter)

E. Case 1 water is “optically complex” coastal green water affected mainly by IOP of water, cDOM, phytoplankton and TSM (total suspended matter)

38. Calcifying phytoplankton. What statement is correct?

A. They are responsible for more than 50% of marine global carbonate flux (e.g. coccolithophorid blooms)
B. They are responsible for ca. 20 % of marine global carbonate flux (e.g. coccolithophorid blooms)
C. They are responsible for significant production of dimethyl sulphide globally
D. They contribute to most of the global marine primary production
E. They are important re-mineralizers of DOM (dissolved organic carbon)

39. What is the most important pigment marker for marine chromophytes? What statement is correct?

A. Chlorophyll b
B. Chlorophyll c
C. Chlorophyll a
D. Fucoxanthin
E. Violaxanthin

40. Phytoplankton bloom dynamics. Which statement is correct?

A. There is are never/rarely a bloom consisting of just one single species (mono-bloom)
B. A bloom always comprises more than 10 species
C. A bloom is defined as phytoplankton biomass >0.1 mg Chlorophyll m^{-3}
D. A bloom is defined of phytoplankton biomass >100 mg Chlorophyll m^{-3}
E. A bloom is defined of phytoplankton causing brownish water

41. Marine prokaryotes: Cyanobacteria. Which statement is correct?

A. They comprise three pigment groups which include group-specific pigment markers Chl a (all autotrophs), Chl b (all green algae) and Chl c (cryptophytes)
B. They comprise two pigment groups with marker pigments fucoxanthin and zeaxanthin
C. They comprise one pigment group with marker pigments zeaxanthin and phycobiliprotein (=phycobilin)
D. They comprise two pigment groups with marker pigments Chl a and zeaxanthin
E. They comprise two pigment groups: Group 1 characterized with myxoxanthophyll (e.g. genus *Trichodesmium*) and group 2 characterized by zeaxanthin and phycobilins (e.g. genus *Synechococcus*)