Section 1: Respiratory System (65 points)

1) It provides CO₂ and O₂ exchange, enables vocalization, provides the sense of smell, helps control the pH of blood, regulates blood pressure, promotes the flow of lymph and venous blood, and helps to remove abdominal contents. (7 points)
2) Angiotensin II
3) B (1 bonus point for simple epithelium is single-layered and stratified epithelium is multilayered)
4) Inferior concha (1 bonus point for 1-2 times)
5) Thyrohyoid, cricotracheal (½ point for each)
6) Three, two (½ point for each)
7) They repair alveolar epithelium (1 point) when squamous alveolar cells are damaged (1 point) and secrete pulmonary surfactant (1 point), which prevents alveoli and small bronchioles from collapsing during exhalation (1 point).
8) During inhalation, the rib cage expands and the parietal pleura follows it outward (1 point). The visceral pleura sticks to the parietal pleura and thus also moves outward (1 point), and because the visceral pleura is the lung surface (1 point), the lungs expand outward as well (1 point). Because there is greater volume, the pressure inside the lungs drops lower than atmospheric pressure, and air rushes into the space (1 point).
9) A
10) Air enters through the nose and passes through the nasal cavity, pharynx, and then larynx (4 points). It then enters the trachea and bronchi, travelling into bronchioles and finally alveoli, where gas exchange occurs (4 points). It then leaves through the bronchioles going to the bronchi, trachea, larynx, pharynx, nasal cavity, and out through the nose (1 point).
11) D
12) 7, chloride ion channel, phosphorylation, cAMP-dependent protein kinase (1 point for each)
13) False
14) B
15) D
16) The tidal volume is the amount of air inhaled or exhaled with a normal breath (1 point), and it is about 500 ml in the image (1 point). The inspiratory reserve volume is the extra amount of air that can be inspired if a person inspires with full force (1 point), and it is
about 3000 ml in the image (1 point). The expiratory reserve volume is the maximum amount of air that can be exhaled with full force (1 point) and it is about 1100 ml in the image (1 point). The residual volume is the amount of air that stays in the lungs even after a forceful expiration (1 point), and it is about 1200 ml in the image (1 point). The inspiratory capacity is tidal volume plus inspiratory reserve volume (1 point), and it is about 3500 ml in the image (1 point). The functional residual capacity is expiratory reserve volume plus residual volume (1 point), and it is about 2300 ml in the image (1 point). The vital capacity is the inspiratory reserve volume plus tidal volume plus expiratory reserve volume (1 point) and it is about 4600 ml in the image (1 point). The total lung capacity is vital capacity plus residual volume (1 point), and it is about 5800 ml in the image (1 point).

17) At the ocean bottom, the partial pressure of oxygen is much higher (1 point), but hemoglobin saturation can still only be 100% maximum (1 point), which is only 3% higher than normal (1 point). Thus, only a small amount of additional oxygen is dissolved in the blood (1 point) and when the blood passes through the capillaries, most of the oxygen is removed (1 point), leaving the $P_{O_2}$ of the capillary blood only slightly higher than normal (1 point). However, alveolar $P_{O_2}$ varies greatly (1 point).

18) True
19) A
20) D

Section 2: Digestive System (33 points)

21) B
22) Parietal
23) B
24) Tight junctions
25) False
26) Lipids are packaged into chylomicrons (1 point) after passing through intestinal absorptive cells (1 point), but chylomicrons are too large to pass through capillary walls (1 point), so the lymphatic system instead absorbs them and later delivers them to the bloodstream (1 point). (1 bonus point for mentioning that Golgi body packages lipids into chylomicrons)

27) The liver secretes bile (1 point), which contains a pigment called bilirubin (1 point). Bacteria metabolize this pigment to urobilinogen (1 point), which lends feces its brown color (1 point). In a malfunctioning liver, bile secretion may not be working properly, so feces can appear white and gray (1 point).

28) D, B
29) D
30) D
31) A
32) Hunger, highest, lowest (1 point each)
33) Thiocyanate
34) Hydrochloric acid, pepsinogen, intrinsic factor, and mucus (1 point for each)
35) In the acidic environment created by HCl (1 point) pepsinogen splits apart to form the active form pepsin (1 point).
36) C
37) Carboxypolypeptidase
38) Cellulose
39) Enterokinase
40) Ultrasound, CT scan (½ point for each)

Section 3: Immune System (41 points)
41) Fluid recovery, immunity, lipid absorption (½ point for each)
42) Memory
43) The thymus is conical, red, and much larger in children (3 points). As an individual ages, however, it starts to shrink and loses lymphatic tissue (2 points), becoming gray and then yellow in color as more fat is stored (2 points).
44) Macrophages and helper T cells (½ point for each)
45) Negative selection
46) B
47) A
48) Oxidizing
49) C
50) In humoral immunity, macrophages phagocytize antigens to present them to nearby B cells and T cells (1 point). The B cells bind to specific antigens and process them (1 point), presenting them on their surface with MHC II molecules (1 point). Helper T cells then bind to the complex and release cytokines to make the B cell divide rapidly (1 point). The daughter cells either become plasma cells, which produce many antibodies that circle through the blood (humor) (1 point), or memory cells (1 point). In cell-mediated immunity, an antigen-presenting cell loads antigens onto the MHC molecule of a T cell (1 point). Cytotoxic T cells then trigger apoptosis in targeted cells (1 point, TH1 cells activate macrophages (1 point) and TH2 cells activate B cells to produce antibodies (1 point).
51) MHC I
52) B
Cytotoxic T cells have receptors on their surface that bind to specific antigens on foreign substances (1 point). They then release perforins (1 point), which make holes in the foreign cell’s membrane and release toxic substances into the cell (1 point). The attacked cell swells and dissolves quickly, and the cytotoxic T cell moves on to other foreign cells (1 point).

Myasthenia gravis

When an allergen with many IgE binding sites encounters a basophil with many IgE antibodies bound to it (1 point), and antibodies bind with the allergen (1 point), altering the surface of the basophil (1 point). The basophil ruptures, releasing histamine into surrounding tissues (1 point).

Section 4: Diagrams (33 points)

Sphenoidal sinus
Nasal cavity
Pharynx
Alveoli
Right lung
Diaphragm
Frontal sinus
Nasal conchae
Nose
Larynx
Trachea
Bronchus
Bronchioles
Left lung
Gallbladder
Duodenum
Minor duodenal papilla
Hepatopancreatic sphincter
Major duodenal papilla
Circular folds
Hepatic ducts
82) Common hepatic duct
83) Cystic duct
84) Bile duct
85) Accessory pancreatic duct
86) Pancreatic duct
87) Duodenojejunal flexure
88) Jejunum
89) Cytotoxic T cells
90) Cytotoxic enzymes
91) Antigen receptors
92) Antigen
93) Attacked cell or foreign cell