ANSWER KEY: Countdown 101

Directions:

The following events are excerpts from a variety of NASA documents that describe events leading up to launch. These events are out of order, and need to be organized by you, quickly, so the countdown clock can start as planned and the next shuttle launch is not delayed. **Note:** Since there are many things happening at the same time, this KEY is for general monitoring of the activity.

Launch Minus 3 Days. The countdown gets underway with the traditional call to stations by the NASA Test Director. This verifies that the launch team is in place and ready to proceed.
Launch Minus 3 Days. The 45th Weather Squadron gives launch forecasts, Ice Team forecasts, SRB recovery forecast, and holds a press conference.
Launch Minus 3 Days. The first item of business is to check out the backup flight system and the software stored in the mass memory units and display systems. Backup flight system software is then loaded into the Shuttle's fifth general purpose computer (GPCs).
Launch Minus 3 Days. Flight crew equipment stowage begins. Final inspection of the orbiter's middeck and flight decks are made, and removal of work crew module platforms begin. Loading preparations for the external tank get underway, and the Shuttle main engines are readied for tanking. Servicing of fuel cell storage tanks also starts. Final vehicle and facility closeouts are made.
T-43 hours and counting. The Shuttle Test Director performs the traditional call to stations and the countdown clock is activated.
T-43 hours and counting. Begin final vehicle and facility closeouts for launch.
T-43 hours and counting. Check out backup flight systems.
T-43 hours and counting. Review flight software stored in mass memory units and display systems.
T-43 hours and counting. Load backup flight system software into the orbiter's general purpose computers.
T-43 hours and counting. Remove middeck and flight deck platforms.
T-43 hours and counting. Activate and test navigational systems.
T-43 hours and counting. Complete preparation to load power reactant storage and distribution system.
T-43 hours and counting. Complete flight deck preliminary inspections.
T-27 hours and holding. The launch pad is cleared of all personnel, while liquid oxygen and hydrogen are loaded into the Shuttle fuel cell storage tanks. Upon completion, the launch pad area is reopened and the closeout crew continues its prelaunch preparations.
T-27 hours and holding. The orbiter's flight control, navigation, and communications systems are activated. Switches located on the flight and mid- decks are checked, and, if required, mission specialist seats are installed. Preparations also are made for rollback of the Rotating Service Structure (RSS).
T-27 hours and holding. This is the first built-in hold and typically lasts four hours. Clear launch pad of all non-essential personnel.
T-27 hours and counting. Begin operations to load cryogenic reactants into the orbiter's fuel cell storage tanks.
T-19 hours and holding. This built-in hold typically lasts four hours.
T-19 hours and holding. Demate the orbiter's midbody umbilical unit.
T-19 hours and counting. Begin final preparations of the orbiter's three main engines for main propellant tanking and flight.
T-19 hours and counting. Fill launch pad sound suppression system water tank.
T-19 hours and counting. Resume orbiter and ground support equipment close-outs.
T-19 hours and counting. Close out the tail service masts on the mobile launcher platform.

T-11 hours and holding. This built-in hold varies in length, but typically lasts 12 to 13 hours.
T-11 hours and holding. Flight crew equipment late stow.
T-11 hours and holding. Move rotating service structure to "park" position.
T-11 hours and holding. Activate the orbiter's inertial measurement units and communications systems.
T-11 hours and holding. Perform ascent switch list.
T-11 hours and counting. Activate the orbiter's fuel cells.
T-11 hours and counting. Clear the blast danger area of all nonessential personnel.
T-11 hours and counting. Switch the orbiter's purge air to gaseous nitrogen.
T-11 hours and holding. This is a planned countdown hold and can last for up to 26 hours and 16 minutes depending on the type of payload, tests required, and other factors. This time is used, if needed, to perform tasks in the countdown that may not have been completed earlier.
T-11 and counting. Countdown is resumed after the built-in hold period has elapsed. The RSS is rolled back, and the remaining crew equipment is installed. Cockpit switch positions are verified, and oxygen samples are taken in the crew area. The fuel cells are activated following a fuel cell flow through purge. Communications with the Johnson Space Center's Mission Control Center (MCC) are established.
T-11 and counting. The launch pad is again cleared of all personnel, while conditioned air that has been blowing through the payload bay and other orbiter cavities is switched to inert gaseous nitrogen in preparation for filling the external tank with its super-cold propellants.
T-11 and counting. The tanking LWO comes on duty to support the tanking operations (filling the ET with liquid hydrogen and oxygen). The LWO prepares a forecast for tanking and provides an update to the NASA Mission Management Team. After the weather briefing from the Shuttle LWO and the SMG forecaster, the Mission Management Team makes the final decision on whether to continue the count and begin tanking operations. The constraints for tanking include winds, lightning, and an average temperature over the past 24 hours <41F.
T-6 hours and holding. This built-in hold typically lasts two hours.
T-6 hours and holding. Launch team verifies no violations of launch commit criteria before loading the external tank with propellants.
T-6 hours and holding. Clear pad of all personnel.
T-6 hours and holding. Chill-down of propellant transfer lines.
T-6 hours and holding. Begin loading the external tank with about 500,000 gallons of cryogenic propellants.
T-6 hours and counting. Finish filling the external tank with its flight load of liquid hydrogen and liquid oxygen propellants.
T-5 hours 20 minutes and holding. The 2-hour built-in hold occurs. During this hold, an ice inspection team goes to the launch pad to inspect the external tank's insulation to insure that there is no dangerous accumulation of ice on the tank caused by the super-cold liquids. Meanwhile, the closeout crew is preparing for the arrival of the flight crew.
T-5 hours 20 minutes and holding. The flight crew, in its quarters at the Operations and Checkout (O&C) Building, eats a meal and receives a weather briefing. Upon arriving at the white room at the end of the orbiter access arm, the crew, assisted by white room personnel, enter the orbiter. Once on board they conduct air-to-ground communications checks with the LCC and MCC. Meanwhile, the orbiter hatch is closed and hatch seal and cabin leak checks are made. The IMU preflight alignment is made and closed-loop tests with Range Safety are completed. The white room is then evacuated and the closeout crew proceeds from the launch pad to a fallback area. At this time, primary ascent guidance data is transferred to the backup flight system.
T-3 hours and holding. This built-in hold typically lasts two hours.
T-3 hours and holding. Perform inertial measurement unit preflight calibration.
T-3 hours and holding. Align Merritt Island Launch Area (MILA) tracking antennas.

T-3 hours and holding. Final Inspection Team proceeds to the launch pad to conduct a detailed analysis of the vehicle as the team walks up and down the entire launch tower.
T-3 hours and holding. Closeout Crew proceeds to the launch pad to configure the crew module for countdown and assist the astronauts with entry into the orbiter.
T-3 hours and counting. As the countdown resumes, the astronauts have awakened, eaten and suited up in their launch suits.
T-3 and counting. Flight crew departs the Operations and Checkout Building (O&C) and proceeds to the Launch Pad.
T-3 hours and counting. Close-out crew check cockpit switch configurations.
T-3 hours and counting. Crew departs for the launch pad and, upon arriving at the pad, begins entry into the orbiter via the White Room. Closeout Crew (who wear white coveralls) assists the astronauts as they don their helmets, adjust and secure their equipment, enter the orbiter, and are strapped into their seats. It takes about 50 minutes to get all flight crew members strapped into their seats.
T-3 hours and counting. When the crew ingresses to the vehicle, a NASA T-38 aircraft takes off to monitor weather conditions at the launch Pad and SLF.
T-3 hours and counting. Complete close-out preparations in the launch pad's White Room.
T-3 hours and counting. Astronauts perform air-to-ground voice checks with Launch Control (Kennedy Space Center) and Mission Control (Johnson Space Center).
T-3 hours and counting. Complete White Room close-out.
T-3 hours and counting. Close-out Crew begins sealing off flight crew compartment.
T-3 hours and counting. Close the orbiter's crew hatch and check for leaks.
T-3 hours and counting. Close-out crew retreats to fallback area.
T-2 hours and 30 minutes and counting. Once all astronauts are aboard the Shuttle, the Closeout Crew seals the crew module hatch about two hours before the launch.
T-2 hours and counting. NASA's two Solid Rocket Booster (SRB) Retrieval Ships, Freedom Star and Liberty Star, will be on station in the Atlantic Ocean about 7.5 miles from the predicted impact points of the rocket boosters. While there, they will perform electronic searches to insure the area is clear of shipping. The two ships departed from Cape Canaveral Air Force Station will be on station in the Atlantic off the coast of Jacksonville, FL at launch time.
T-1 hour, 40 minutes and counting. The RECCE aircraft commander lands the T-38 and then takes off in the Shuttle Training Aircraft approximately 1 hour 40 minutes before launch. The Shuttle Training Aircraft is an aircraft modified to fly and handle similarly to the Orbiter, and the astronauts use this to train for flight. The aircraft is used to monitor weather conditions at the Pad and determine the approach conditions at the SLF.
T-50 minutes and counting (approximately). Pilot astronaut configures switches in the cockpit to pre-activate the orbiter's three water spray boilers. Each of the orbiter's three hydraulic systems has a boiler used to cool the system's hydraulic fluid and Auxiliary Power Unit lubrication oil. Boiler steam is vented overboard. During the launch, orbital checkout, and reentry through landing phases, the spray boilers are activated if the hydraulic fluid exceeds 208 degrees Fahrenheit or 250 degrees Fahrenheit for the lubrication oil. The spray boilers are located in the orbiter's aft fuselage and hold about 120 pounds of water.
T-45 minutes and counting. The Terminal Count Range safety closed-loop test begins. This test verifies the paths the destruct signal would travel and confirms that the Shuttle’s range safety receiver responds correctly to the commands sent. This is also a health check of the range safety signal. Console operators in the Eastern Test Range Control Center at Cape Canaveral Air Station will also get verification that the orbiter has received the signal. This test normally takes about five minutes to complete and is done to ensure down range shipping lanes and the booster splashdown area are clear and that the tracking station is ready.

T-45 minutes and counting. NASA Test Director coordinates with Mission Control in Houston, TX to switch the orbiter's S-band antennas to high power mode and to configure the onboard communications system so that it will transmit and receive by radio at liftoff (During launch countdown, communications with the orbiter are hard wired.). This system can communicate either directly between the orbiter and ground or through the TDRS satellite system.
T-40 minutes and counting. The Ground Launch Sequencer mainline computer program is active and begins processing data. This program will monitor various key commands and systems prior to assuming control of the countdown at the T-9 minute and counting mark.
T-30 minutes and counting. The Orbital Maneuvering System (OMS) gaseous nitrogen tanks have been pressurized for launch. Gaseous nitrogen is used to operate the valves allowing the hypergolic propellants to flow into the OMS engines during flight.
T-30 minutes and counting. The post launch inspection and safing teams begin assembling approximately one mile from the launch pad.
T-30 minutes and counting. Within the next minute or so, the preflight test of the orbiter's Master Events Controller (MEC) is completed. The MEC relays commands from the orbiter's computers to fire explosive charges to the Solid Rocket Booster hold-down bolts at launch and to separate the tank and twin boosters in flight.
T-25 minutes. The Closeout Crew has evacuated the launch pad.
T-20 Minutes and Holding. A built-in hold begins. Program Managers will be called at this time to make sure each of their departments is "Go" for launch. Commander performs a series of voice checks, configures Return-To-Launch-Site (RTLS) altimeter settings, and completes other preflight checklist items.
T-20 minutes and holding. This built-in hold typically lasts 10 minutes.
T-20 minutes and holding. The Shuttle Test Director conducts final launch team briefings.
T-20 minutes and holding. Complete inertial measurement unit preflight alignments.
T-20 Minutes and Holding. The Kennedy Space Center Launch and Johnson Space Center Flight Directors are briefed about impending launch and RTLS weather conditions.
T-20 minutes and counting. On-board computers are commanded to their launch configuration, and fuel cell thermal conditioning begins. Orbiter cabin vent valves are closed, and the backup flight system transitions into its launch configuration.
T-9 minutes and holding. Another planned 10-minute hold occurs.
T-9 Minutes. The last built-in hold of the countdown takes place. Readiness polls are conducted by the three teams that together comprise the Shuttle Launch Team. The NTD verifies that the prime Launch Team is reporting no violation of the Launch Commit Criteria; the Engineering Director verifies no constraints to continuing with the final count; and the Mission Management Team Chairman verifies that there are no open issues with any of the senior element managers. These three verifications are communicated to the Shuttle Launch Director, who conducts a KSC management poll. Assuming all responsible personnel are in agreement, the Launch Director gives his permission to proceed with the countdown to the NTD. The NTD in turn sets in motion the final nine minutes of the countdown, automatically controlled by the Ground Launch Sequencer. At this point, the Ground Launch Sequencer (GLS) is turned on and the terminal countdown starts. All countdown functions are now automatically controlled by the GLS computer located in the Firing Room Integration Console.
T-9 minute and holding. All consoles will be asked for their "Go or No-go" decisions. Safety is the most important consideration. Each console has displays and gauges showing each department's responsibility during the launch. They are looking for "out of specification" readings that could hold the countdown.
T-9 minutes and counting. Countdown is now under the control of the (GLS) Ground Launch Sequencer, a major mainframe computer that controls the final countdown.

T-7 minutes, 30 seconds, and counting. The orbiter access arm is retracted. Should an emergency occur requiring crew evacuation from the orbiter, the arm can be extended either manually or automatically in about 15 seconds.
T-5 minutes, 15 seconds, and counting. The MCC transmits a command that activates the orbiter's operational instrumentation recorders. These recorders store information relating to ascent, on-orbit and descent performance during the mission. These data are analyzed after landing.
T-5 Minutes. This is where the “Go or No-go” decision has to be made.
T-5 minutes and counting. The crew activates the Auxiliary Power Units (APU) to provide pressure to the Shuttle's three hydraulic systems, which move the main engine nozzles and the aero-aerosurfaces. Three good APUs are needed to proceed for launch.
T-5 minutes and counting. The firing circuit for SRB ignition and the range safety destruct system devices are mechanically enabled by a motor-driven switch called the safe and arm device.
T-5 Minutes. If there is a possibility that the weather will change, the count holds here.
T-4 minutes, 55 seconds, and counting. The liquid oxygen vent on the external tank is closed. It had been opened to allow the super-cold liquid oxygen to boil off, thus preventing over pressurization while the tank remained near its full level. Now, with the vent closed, preparations are made to bring the tank to its flight pressure.
T-4 minutes and counting. The final helium purge of the Shuttle's three main engines is initiated in preparation for engine start. Five seconds later, the orbiter's elevons, speed brakes, and rudder are moved through a pre-programmed series of maneuvers to position them for launch. This is called the aerosurface profile.
T-3 minutes, 30 seconds, and counting. The ground power transition takes place, and the Shuttle's fuel cells transition to internal power. Up to this point, ground power had augmented the fuel cells.
T- 3 minutes, 25 seconds, and counting. The main engine nozzles are gimbaled through a pre-programmed series of maneuvers to confirm their readiness.
T-2 minutes, 50 seconds, and counting. The external tank oxygen vent hood, known as the beanie cap, is raised and retracted. It had been in place during tanking operations to prevent ice buildup on the oxygen vents.
T-2 minutes, 35 seconds, and counting. The piping of gaseous oxygen and hydrogen to the fuel cells from ground tanks is terminated, and the fuel cells begin to use the on-board reactants.
T-1 minute, 57 seconds, and counting. The external tank's liquid hydrogen is brought to flight pressure by closing the boil off vent, as was done earlier with the liquid oxygen vent. However, during the hydrogen boil off, the gas is piped out to an area adjacent to the launch pad where it is burned off.
T-31 seconds and counting. The Shuttle's on-board computers start their terminal launch sequence. Any problem after this point will require calling a "hold" and the countdown recycled to T-20 minutes. However, if all goes well, only one further ground command is needed for launch. This is the "Go For Main Engine Start," which comes at the T-10-second point. Meanwhile, the Ground Launch Sequencer (GLS) continues to monitor more than several hundred launch commit functions and is able automatically to call a "hold" or "cutoff" if a problem occurs.
T-31 seconds. The Ground Launch Sequencer (GLC) "hands off" control of the countdown from itself to the on-board computers in the orbiter.
T-28 seconds and counting. The SRB booster hydraulic power units are activated by a command from the GLS. The units provide hydraulic power for SRB nozzle gimballing.
T-16 seconds and counting. The nozzles are commanded to carry out a pre-programmed series of maneuvers to confirm they are ready for liftoff.
T-16 seconds and counting. The sound suppression system is turned on, and water begins to pour onto the deck of the MLP and pad areas to protect the Shuttle from acoustical damage at liftoff.
T-11 seconds and counting. The SRB range safety destruct system is activated.

T-10 seconds and counting. The "Go For Main Engine Start" command is issued by the GLS. (The GLS retains the capability to command main engine stop until just before the SRBs are ignited.) At this time, flares are ignited under the main engines to burn away any residual gaseous hydrogen that may have collected in the vicinity of the main engine nozzles. A half second later, the flight computers order the opening of valves, which allow the liquid hydrogen and oxygen to flow into the engine's turbopumps.
T-6.6 seconds and counting. The three main engines are ignited at intervals of 120 milliseconds. The engines throttle up to 90 percent thrust in 3 seconds.
T-6 seconds. Things are happening very quickly now. The computer systems are conducting tests and checks much faster than humans could. If something goes wrong, the computer will shut down the engines, and everyone in the control room goes to the red pages of their countdown books.
T-6 seconds. When the Space Shuttle Main Engines ignite, the Shuttle leans a bit in a phenomenon called "twang." The Shuttle straightens back to the vertical as the countdown reaches T-0.
T-3 seconds and counting. If the engines are at the required 90 percent, SRB ignition sequence starts. All of these split-second events are monitored by the Shuttle's four primary flight computers.
T-0. Lift Off. The holddown explosive bolts and the T-O umbilical explosive bolts are blown by command from the on-board computers, and the SRBs ignite. Once the Shuttle's twin solid rocket boosters ignite at T-0, responsibility for the mission switches from KSC to the Mission Control Center at Johnson Space Center in Houston. KSC once again assumes responsibility after the orbiter has landed and the flight crew has exited the vehicle.
T-0. The Shuttle is now committed to launch. The mission elapsed time is reset to zero, and the mission event timer starts. The Countdown is now over. We begin counting in Mission Elapsed Time: MET.
T+7 seconds and counting. The Shuttle lifts off the pad and clears the tower. Mission control is handed over to JSC after the tower is cleared.